ON

INTELLIGENCE.

ON

INTELLIGENCE.

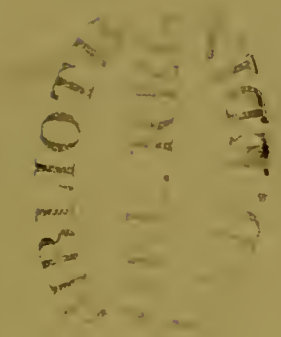
BY

H. TAINE.

TRANSLATED FROM THE FRENCH BY

T. D. HAYE,

AND REVISED BY THE AUTHOR.



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NOTICE.

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THE Work an author has most fully meditated ought to be honoured by the name of the friend whom he has most respected. I dedicate this book to the Memory of FRANZ WOEPKE, Orientalist and Mathematician, who died at Paris in March, 1864.

H. TAINE.

PREFACE.

If I am not mistaken, we mean now-a-days by Intelligence, what was formerly called Understanding or Intellect—that is to say, the faculty of knowing; this, at least, is the sense in which I have taken the word.

At all events, I here intend to examine our knowledge, that is to say, our cognitions, and nothing else. The words *faculty, capacity, power,* which have played so great a part in psychology, are only, as we shall see, convenient names by means of which we put together, in distinct compartments, all facts of a distinct kind; these names indicate a character common to all the facts under a distinct heading; they do not indicate a mysterious and profound essence, remaining constant and hidden under the flow of transient facts. This is why I have treated of cognitions only, and, if I have mentioned faculties, it has been to show that in themselves, and as distinct entities, they do not exist.

Such a precaution as this is very necessary. By means of it, psychology becomes a science of facts; for our cognitions are facts; we can speak with precision and detail of a sensation, of an idea, of a recollection, of a prevision, as well as of a vibration, or other physical movement; in the one case as in the other there is a fact in question; it may be reproduced, observed, described; it has its precedents, its accompaniments, its consequents. In little, well-selected, important, significant facts, stated with full details and minutely noted, we find at present the materials of every science; each of them is an instructive specimen, the head of a rank, a salient example, a clear type to which a whole row of analogous cases conform; our main business is to know its elements, how they arise, in what manner

and under what conditions they combine, and what are the constant effects of combinations so produced.

Such is the method it has been attempted to follow in this work. In the first part, the elements of knowledge have been determined; by consecutive reductions we have arrived at the most simple elements, and have passed from these to the physiological changes which are the condition of their origin. In the second part, we have first described the mechanism and general effect of their combination; then, applying the law we have discovered, we have examined the elements, formation, certitude, and range of the principal kinds of our knowledge, from that of individual things to that of general things, from the most special perceptions, previsions, and recollections, up to the most universal judgments and axioms.

In these inquiries, Consciousness, our principal instrument, is not sufficient in its ordinary state; it is no more sufficient in psychological inquiries than the naked eye in optical inquiries. For its range is not great; its illusions are many and invincible; it is necessary continually to beware of it; to test and correct its evidence, nearly always to assist it, to present objects to it in a brighter light, to magnify them and construct for its use a kind of microscope or telescope; at all events, to arrange the surroundings of the object, to give it the necessary relief by means of contrasts, or to find beside it indications of its presence, indications plainer than it is, and indirectly pointing out its nature.

Here lies the principal difficulty of the analysis.—As far as pure ideas and their relations with names are concerned, the principal aid has been afforded by names of numbers, and, in general, by the notations of arithmetic and algebra; thus we have brought again into light a great truth guessed at by Condillac, and which has lain for a century dormant, buried, and as though lifeless, for want of satisfactory evidence.—As to images, their effacement, their revival, their antagonist reductives, the necessary magnifying is found in the singular and extreme cases observed by physio-

logists and medical men, in dreams, in somnambulism and hypnotism, in illusions and the hallucinations of sickness.— As to sensations, significant instances are found in the sensations of sight, and especially in those of hearing. By means of such evidence, and of the recent discoveries of physicists and physiologists, we have attempted to construct or sketch out the whole theory of elementary sensations, to advance beyond the ordinary bounds, up to the limits of the mental world, to indicate the functions of the principal parts of the brain, to conceive the connexion of molecular nervous changes with thought.— Other abnormal cases, borrowed both from students of insanity, and from physiologists, have enabled us to explain the general process of illusion and rectification, whose successive stages constitute our various kinds of knowledge. — After this, to elucidate our knowledge of bodies, and of ourselves, valuable indications have been found in the profound and closely reasoned analyses of Bain, Herbert Spencer, and Stuart Mill, in the illusions of persons who have lost limbs, in all the different illusions of the senses, in the education of the eye in persons born blind who have recovered their sight by operations, in the singular alterations which the idea of self undergoes during sleep, hypnotism, and madness.—We have then been able to enter upon the examination of the ideas and general propositions which make up the sciences, properly so called, to profit by Mr. Mill's acute and accurate inquiries respecting Induction, to establish against Kant and Mill a new theory of necessary propositions, to study by a series of examples what is termed the explanatory reason of a law, and to conclude with general views on science and nature, while pausing before the metaphysical problem which is the first and last of all.

Between psychology thus conceived and history as it is now written the relationship is very close. For history is applied psychology, psychology applied to more complex cases. The historian notes and traces the total transformations presented by a particular human molecule or group of human molecules ;

and, to explain these transformations, writes the psychology of the molecule or group; Carlyle has written that of Cromwell; Sainte-Beuve that of Port Royal; Stendhal has made twenty attempts on that of the Italians; M. Renan has given us that of the Semitic race. Every perspicacious and philosophical historian labours at that of a man, an epoch, a people, or a race; the researches of linguists, mythologists, and ethnographers have no other aim; the task is invariably the description of a human mind, or of the characteristics common to a group of human minds; and, what historians do with respect to the past, the great novelists and dramatists do with the present. For fifteen years I have contributed to these special and concrete psychologies; I now attempt general and abstract psychology. To comprise it exhaustively, there would be required a theory of the Will in addition to the theory of the Intelligence; if I may judge of the work I do not venture to undertake by that which I have attempted to accomplish, my strength is not equal to this; all that I venture to hope is that the reader will grant me his indulgence, in consideration of the difficulty of the task and the length of the effort.

H. Taine.

December, 1869.

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ON INTELLIGENCE.

PART THE FIRST.

THE ELEMENTS OF KNOWLEDGE.

BOOK I.

OF SIGNS.

CHAPTER I.

OF SIGNS IN GENERAL AND OF SUBSTITUTION.

I. If we ascend the Arc de l'Étoile, and look down on the Champs Élysées, we see a number of black or variously coloured specks stirring about on the roadway or pavements. That is all our eyes distinguish. But we know that each of these specks is a living body, with active limbs, a wise economy of organs, and a thinking brain actuated by some project or inward desire—in short, is a human being. The presence of the specks has indicated the presence of persons. The first have been signs of the second.

Associations of this kind are continually being met with.—At night we look up to the starry sky, and say to ourselves that each of these brilliant points is an enormous mass like the sun.—When we walk in the fields on an autumn evening, we see the blue smoke rising calmly in the distance, and think at once of the slow fires with which the peasants are burning up the stubble.—We turn over sheets of music,

and, while the eye follows the black and white marks with which the lines are dotted, we hear mentally the sounds they indicate.—A sharp cry of a particular tone comes from a neighbouring room, and we picture to ourselves the face of a child, crying no doubt because he has hurt himself. The greater part of our ordinary judgments are made up of connections like these. When we drink, or walk, or use our limbs for any purpose, we foresee, by means of a perceived fact, a fact which we do not yet perceive; animals do the same; according to the colour or smell of an object, they eat or leave it.—In all these cases a present experience suggests the idea of another possible experience; from the first we imagine the second: the perception of an event, object, or character, arouses the conception of another event, object, or character. When we touch the first link of the couple we picture to ourselves the second link, and the first is the sign of the second.

II. In this great family of signs there is one species whose properties are remarkable; these are *names*.

Let us first consider proper names, which are the easier to study from each one denoting some particular, precise thing; as, for example, the names Tuileries, Lord Palmerston, Luxembourg, Notre Dame, &c. These clearly belong to the family we have just described, and each of them is the sensible and apparent first term of a couple. When I hear the word Lord Palmerston pronounced, or read the fourteen letters of which it is made up, I form a mental image of his brisk erect figure, gesticulation, and smile, just as I have seen him in his place in Parliament. Again, when I read or hear the word Tuileries, I picture more or less vaguely, in more or less mutilated forms, a level garden, flower-beds enclosed with rails, marble statues, the rounded heads of chestnut-trees, the fall and plume of a fountain, and the rest. A short insignificant sensation, acting through our eyes or ears, has the property of calling up in us a certain image, or series of images, more or less definite, and the connection between the first and second terms of this couple is so precise, that in a hundred million instances,

and for two millions of men, the first term invariably calls up the second.

III. Suppose now that instead of dwelling on the word Tuileries, and calling up the different images connected with it, I glance quickly at a phrase like this:—"There are many public gardens in Paris, both small and great, some no bigger than a drawing-room, others as large as a park, the Jardin des Plantes, the Luxembourg, the Bois de Boulogne, the Tuileries, the Champs Élysées, the squares, besides the new parks which are being laid out, all very neat and well looked after." I ask the ordinary reader who has just gone through this list with ordinary speed, if, when his eye ran over the word Tuileries, he saw mentally, as before, some fragmentary image, some patch of blue sky appearing through trees, the attitude of some statue, some vaguely extending avenue, the sparkling of water in a basin?—Assuredly not, his eye ran over it too quickly; there is a notable difference between this and the preceding operation. In the first, the sign aroused pictures more or less faded of the sensation, revivals more or less enfeebled of the experience; in the second, the sign did not arouse them. In the one case, the two links of the couple appear; in the other, the first link alone appears. Between these two operations are an infinite number of intermediate states occupying the whole interval; these states connect the intense half-sight with the dry notation, by a series of degradations, rubbings out, and losses, which strip by degrees the complete and puissant image, till they leave us nothing but a simple word.

This word so reduced is not however a lifeless symbol, without trace of signification; it is more like the trunk of a tree, stripped indeed of its leaves and branches, but capable of reproducing them; we understand it as we pass it, and with whatever speed we may pass it; it does not come to us as a stranger, or strike us as an intruder; in its long association with the experience and image of the object, it has contracted certain affinities and repugnances; and in passing through us carries with it this retinue of affinities

and repugnances; however briefly we retain the word, the image to which it corresponds commences to form; the image accompanies the word in a nascent state, and, though not actually formed, acts on us as if it were. Read, for instance, a sentence like this:—"London, the capital of England, has several fine gardens—Hyde Park, Regent's Park, and the Tuileries."—We experience a certain shock and surprise; we point involuntarily in two directions, towards Paris and towards a far distant city. The image of the Tuileries is aroused, with the Seine and quays beside it, and we are arrested when we try to transport them elsewhere. But before the image appeared, we experienced a resistance in the word itself, a resistance which was strengthened and renewed when the image reappeared. Prolong and vary the experiment: you will find in the word a system of tendencies all corresponding to those of the image, all acquired by it in its connection with the experience and the image, but now spontaneous, and acting, sometimes to connect it with, sometimes to sever it from, other words or groups of words, images or groups of images, experiences or groups of experiences. In this way the simple name is enabled to take the place of the image it arouses, and consequently, of the experience it recals; it performs their office and becomes their *substitute*.

IV. In the case we have considered, the obliteration of the image forming the second member of the couple is, as generally happens with proper names, gradual and involuntary. Let us consider another case, in which we suddenly and voluntarily suppress it; the reader will then see the operation more clearly set out.

My garden is surrounded by a hedge, and my fruit is stolen; I determine on enclosing it with a wall. I get what workmen I can in the village—four, for instance—and at the end of the day I find they have built twelve metres of wall. This is not fast enough; I send to the next village for six other workmen, and ask myself how many metres a day will be added to the wall. To find out this, I no longer picture to myself workmen with their blouses and

trowels—the wall with its stones and mortar, but replace my first workmen by the figure four, the first amount of work by the figure twelve, the whole of the workmen by the figure ten, the unknown amount of work they will do by the sign x, and write down the following proportion :—

$$4 : 12 :: 10 : x = \frac{12 \times 10}{4} = 30.$$

Henceforth, barring accident or drunkenness, if the new men work like the old, and all continue to work together as the first four began, my ten men will build thirty metres a day. Operations of this kind occur daily, and all practical calculations are made in this way. For the real objects first imagined, figures are substituted which replace them partially; they replace them in the only point of view in which we need consider them, that is, in point of number. This once effected, we forget the objects represented; they recede into the background; we only consider the figures, we assemble, compare, transpose, and manipulate them as more convenient equivalents, and the figure we finally arrive at indicates the object, or group of objects, at which we wish to arrive.

Substitution goes further than this, and figures substituted for things have in turn letters substituted for them. After several similar calculations, I observe that in all such cases the proportion is written in the same way, that the first figure always represents the first workmen; the second, their work; the third, the whole number of workmen; the fourth, the unknown work; and thus I pass from arithmetic to algebra. Henceforth I replace the first figure by A, the second by B, the third by C, and write down as follows :—

$$A : B :: C : x = \frac{B \times C}{A.}$$

And I see that, in every such case, if I want to know the amount of work which will be done by all the workmen, it will be sufficient to multiply their number by that repre-

senting the work done by the first lot, and then to divide the product by the number of the workmen first employed.

Instead of this simple case, let us consider the labour of an analyst who writes equations by the hour. He lays aside the figures, but indirectly he is working on them, just as an arithmetician lays aside the facts, but works indirectly on the facts. He effaces figures from his mind as the other effaces things. Each of them arranges and combines signs, and these signs are *substitutes*. The fact is, they are not, like proper names, substituted for the whole of the object they represent, but merely for a portion or an aspect of such object. The letter used in algebra does not fully replace the arithmetical cipher with its precise quantity, but only as regards its function and place in the equation it enters into. The arithmetical cipher does not fully replace the thing it stands for, with all its qualities and characters, but only, as regards quantity and number. Each replaces part only of the imagined object, that is to say, a fragment—an extract; the cipher a more complex extract; the letter a less complex one, that is to say, an extract from the first extract. But the substitution, though partial, is none the less actual. Two complete and infinitely fertile sciences depend on it, and derive their efficacy from it.—The reader must pardon me for dwelling on simple remarks like these. In the formation of *couples*, such that the first term of each suggests the second term; and, in the aptitude of this first term to stand, wholly or partially, *in place of* the second, so as to acquire, either a definite set of its properties, or all those properties combined, we have, I think, the first germ of the higher operations which make up man's intelligence; we shall now consider them in detail.

CHAPTER II.

OF GENERAL IDEAS AND SIMPLE SUBSTITUTION.

I. NAMES, as we know, are divided into proper and common; and these are correctly distinguished by saying that the first, as Cæsar, Tuileries, Cromwell, correspond to a single object; while the second, as tree, triangle, colour, correspond to an indefinite group of objects. These last are the most numerous, and the most in use in every individual mind; there are thirty or forty thousand of them in a language, and they make up of themselves the whole dictionary. Further than this, they are the most important; by their aid we make classifications, judgments, and reasonings, and pass, in short, from crude, loose experience, to orderly complete knowledge. Let us consider them attentively. We should attain a truth of capital importance, and infinite in its consequences, could we determine, not as grammarians and logicians, but as psychologists, their true nature and precise office.

Like all signs, and especially like all names, each one is the first term of a couple, and draws with it a second term. But this second term has remarkable characteristics, which distinguish it from all others, and give the name peculiar qualities. Logicians and grammarians tell us rightly that a common name, like tree or polygon, is a general or abstract name.—It is general because it corresponds to a class (*genus*) or group of similar objects; the name of tree to all trees, poplars, oaks, cypress, birch, &c.; the name of polygon to all polygons, triangles, quadrilaterals, pentagons, hexagons, &c.—It is abstract, because it denotes an *extract*, that is, a portion, of an individual, and a portion which is found in every individual of the group; the name tree expresses

the quality common to all kinds of trees, poplars, oaks, cypress, birch, &c.; that of polygon represents the quality common to all sorts of polygons, triangles, quadrilaterals, pentagons, hexagons, &c.—We see the connection between these two characters of a name; it is general because it is abstract; it corresponds to a whole class, because the object it denotes, being but a fragment, may be found in all the individuals of the class, which, similar in this point, remain, nevertheless, dissimilar in other points. Here we have a couple of a new kind, since its second term is not an object of which we can have perception and experience, that is to say, an entire and determined fact, but a portion of a fact, a fragment forcibly and artificially severed from the natural whole to which it belongs, and without which it cannot subsist.

II. Can we have experience, perception, or sensible representation of this detached and isolated fragment? Assuredly not; for that would be a contradiction.—When I have seen on the slate triangles, quadrilaterals, pentagons, hexagons, &c.; and, in contrast, beside them, circles and ellipses, and call the first polygons, I have not mentally a sensible representation of a pure or abstract polygon; for the pure polygon is a figure with several sides, but whose sides do not make up any particular number; hence all experience and sensible representation are excluded; for since the sides are many, they make such a number as three, four, five, six, &c. In saying many, we mean a determined fixed number. To tell one to see or imagine many sides, and at the same time not to see or imagine three, four, or any definite number of sides, is, in one breath, to order and forbid the same operation.—Similarly, when having seen in the country thirty different trees, oaks, lime trees, beech, and poplars I use the word tree, I do not find in my mind a coloured figure representative of a tree in general; for a tree in general has height, a trunk, leaves, &c., without having any particular height, trunk, or leaves; and it is impossible to represent to one's self size and form, unless the size and form are of some kind or other—that is to say, in-

dividual and precise. In fact, at the word tree, especially if read slowly and attentively, there rises in me a vague image—so vague that I cannot for the moment say whether it is a fir or an apple tree. And so in hearing the word polygon, I trace in my mind, but very indistinctly, lines cutting each other, and tending to enclose a space, without knowing whether the figure in process of construction will turn out quadrilateral or a pentagon. But this uncertain image is not the abstract tree, nor the abstract polygon; the softness of its outline does not hinder its having a particular outline; it is shifting and obscure, and the object denoted by the name is neither shifting nor obscure; it is a very precise extract, and can often be defined exactly. We can express with rigorous exactness what constitutes a triangle, and, almost as exactly, what constitutes an animal. The triangle is a figure enclosed by three lines, which cut each other in pairs, and not that undecided image, on a dusky or whitish ground, with angles more or less acute, which shifts continually, becoming at will scalene, or isosceles, or right angled. The animal is an organized body which is nourished, reproduces its species, feels, and moves, and not that formless and varying thing, changing from vertebrate to articulate or to mollusc, and only emerging from its indistinctness when it takes the colour, size, and structure of an individual.

Thus we find a wide gulf between the vague and shifting image which the name suggests, and the precise and fixed extract which the name denotes.—The reader may convince himself of this by considering the word myriagon and its meaning. A myriagon is a polygon with ten thousand sides. It is impossible to imagine such a thing even when definite and special, much less when general and abstract. However lucid and comprehensive may be the mind's view; after five or six, twenty or thirty lines drawn out consecutively with great difficulty, the image becomes confused and indistinct; and yet my conception of a myriagon has nothing confused or indistinct about it. What I conceive, is not a myriagon like this, incomplete and tumbling to

pieces, but a complete myriagon all whose parts co-exist simultaneously; I can hardly imagine the first, but can readily conceive the second. What I conceive then, differs from what I imagine; and my conception is not the same thing as the shifting figure which accompanies it. But, on the other hand, this conception exists; there is something in me representing the myriagon, and corresponding to it exactly. In what then does this internal representative—this exact correspondent—consist? and what passes within me when I hear a general name, and, by means of it, think of a quality common to many individuals—of a general thing—in short, of an abstract character?

III. To answer this, let us consider in order several cases in which, when we have gone through a series of similar objects, we have mentally extracted from them a quality, or general character, which we denote by an abstract name. The reader has no doubt visited galleries of pictures arranged in schools; if we walk for a couple of hours among the works of Titian, Tintoret, Giorgione, and Veronese, and on leaving seat ourselves on a bench, and close our eyes, we experience reminiscences of what we have seen; we see again inwardly such and such a fair or rosy half-bending figure, some grand old man majestically draped in silken robes, strings of pearls on naked arms, chestnut hair curling over a snowy neck, colonnades of veined marble rising against a blue sky, here and there the sprightly figure of a little girl, the smile of a goddess, the ample proportions of a smooth shoulder, the blaze of red hangings against a green background; in short, a hundred partial and disorderly revivals of what we have just seen. If, at this moment, we seek for the dominant character ruling in this various world, we find nothing; we feel indeed that it is beautiful, but do not yet distinguish in what the beauty lies; we are acted on by twenty different tendencies which rise and as quickly fade; we attempt such expressions as voluptuous, rich, facile, luxuriant; they are not suitable, or but partially so. We then begin again by dividing our inquiries, we pass by turns in review landscapes, architecture, dress, types, expressions,

attitudes, colouring; we find for each of these fragments some principal and striking trait, we attempt to note them in passing by a familiar or exaggerated word, then, collecting all these summaries we try to summarize them further in some abbreviative phrase which may serve as a focus for all these dispersed rays. We approach our object, and at last *a definitive, or nearly definitive, tendency is disengaged.* It appears, in words, by such expressions as expansiveness, happiness, noble pleasure; while our inner sight has at the same moment seized on some corresponding image, an opening flower, a smiling face, a bending unconstrained form, the rich and full harmony of sweet-toned instruments, the breath of perfumed air in the country; here are expressive comparisons and metaphors, that is to say, sensible representations, special recollections, revived sensations, all analogous in tone and character to what we have just experienced. They are effects and *expressions* of the final tendency which has been formed.—In the case of an artist, the formation, disengagement, and effects of the tendency are plainer still. The whole body speaks; often, if at a loss for a word, a gesture expresses the meaning; a grimace, a start, an imitative noise, becomes a sign in place of a name; to represent an avenue of old oaks, the stature becomes erect, the feet are planted firmly on the ground, the arms extend stiffly, or form sharp angles at the elbows; to represent a cluster of honeysuckle or ivy, the stretched-out fingers trace arabesques in the air, while the muscles of the face assume changing folds.—This mimicry is natural language, and with some habit of internal observation you guess the corresponding mental state. In fact, the experiences we undergo, and their images which recur to us, are not pure knowledge; they affect us while they teach us; they are at once a disturbance and a light. Each one of them is accompanied by one or many slight shocks, and each of them has for effect one or more slight tendencies. Beneath images and experiences, vegetation that thrives in the light, there is an obscure world of impulsions, repugnances, startling shocks, sketchy, disorderly, dis-

cordant solicitations, which we can barely distinguish, but which are nevertheless the inexhaustible and ever-springing source of our actions. These are the countless little emotions which, at the close of our prolonged examination, sum themselves up in an impression of a whole, and consequently, in a final and definite tendency, and this tendency results in an expression. Whatever this expression may be—the imitative gesture of the artist, the metaphorical half-sight of the poet, the expressive pantomime of the savage, the animated tones of the impassioned man, the dry tone and abstract language of the calm reasoner—the mental operation is always the same; and if we inquire into what passes in us when, from several perceptions, we disengage a general idea, we find—and find only—the formation, completion, and preponderance of *a tendency which urges an expression,* and, among other expressions, *a name.*

To revert to our first example.—I observe in turn pines, ash, chestnuts, beech, oak, a whole forest; I remark the springing trunk and spreading branches which form the two distinctive characters of a tree; I form a general conception of a tree and use the word tree. This simply means that a certain tendency in my mind, corresponding to these two characters—and to these two characters only—has at last become distinct and predominant. On fifty consecutive occasions, and without a single contradictory instance, it has in turn been aroused at the sight of fifty trees; and it only has been aroused on each one of these fifty occasions. All other tendencies corresponding to the peculiarities of the different trees, are effaced and annulled by mutual contradiction; it alone survives, and results, as do all tendencies, in an expression. Mentally, this result is an image, more or less vague—that of a slender, then spreading stem; outwardly, it becomes the attitude and imitative gesture of the body; in primitive language, among infant races, at the origin of speech, it is a poetical and figurative imitation of another kind, of which we find fragments here and there; now-a-days, it has become a simple word, which we learn purely by way of notation, the dry remains

of the little symbolical drama and living mimiery by which the first inventors, true artists, translated their impressions.

IV. The reader now sees how it is we conceive a general quality; when we have seen a series of objects possessing a common quality, we experience a certain *tendency*, a tendency which corresponds to the common quality, and to it alone. It is this tendency which calls up the name; and when it arises the name only is imagined or pronounced. We do not perceive qualities or the general characters of things; we only experience in their presence such and such a distinct tendency, which, in spontaneous language, results in a certain mimicry, and, in our artificial language, in a certain name. We have, strictly speaking, no general ideas; we have tendencies to name and names.—But a tendency is nothing distinct in itself; it is the commencement, the rudiment, the sketch, the approximation, whether easy or difficult, to something, image, or name, or other determinate act, which is its full development and accomplishment; it is the elementary form of the act which is its final state.—As to positive and definite acts, when we conceive or know abstract qualities, all that passes in us are names, some in process of being expressed or mentally imagined; others already expressed and imagined. What therefore we call a general idea, a comprehensive view, is only a name; not the simple sound that vibrates in the air and strikes our ear, or the collection of letters which blacken the paper and attract the eye, not even these letters perceived mentally, or this sound pronounced mentally, but this sound or these letters endued, when we experience or imagine them, with a double property, that of arousing in us images of individuals belonging to a certain class, and of these individuals only; and the property of reviving when, and only when, an individual of this same class is present to our memory or experience.—The only difference between the word *tree*, which has a meaning, and the word *eter*, which has none, is that on hearing the second we do not imagine any object or series of objects belonging to a distinct class, and there is no

object or series of objects belonging to a distinct class which suggest to us such a word, whilst on hearing the first word we involuntarily picture to ourselves an oak, a poplar, a pear tree, or some other tree, and on seeing a tree, of whatever kind, we involuntarily pronounce the word tree. Instead of *eter* put the word *arbre*; to any one unacquainted with French, the two words are of equal value, and result in the same want of effect; to a Frenchman the word *arbre* has precisely the properties which we have just found in the word tree.—A name, then, which we understand is a name connected with all the individuals which we can perceive or imagine belonging to a certain class, and only with the individuals of this class. In this way it corresponds to the common and distinctive quality which constitutes the class and separates it from other things, and corresponds to this quality only; wherever the quality is, there is the name; whenever this quality is absent there is no name; it is aroused by it, and by it only.—Thus it becomes its mental representative, and the substitute of an experience to which we cannot attain. It stands in place of this experience, it fulfils its office, and is equivalent to it.

Admirable and spontaneous artifice of our nature: we can neither perceive general qualities nor maintain them separate in our minds; and yet, they are the precious veins which constitute the essence and are the foundation of the classification of things, and, to enable us to emerge from gross animal experience, to seize the order and internal structure of the world, we must draw them from their ore and conceive them apart.—We make a circuit, we associate with each abstract and general quality a little special complex fact, a sound, a figure easy to imagine and reproduce; we make the association so close and precise, that henceforward the quality cannot appear or be missing in things without the appearance or absence of the name in our minds, and reciprocally. The couple so formed resembles those physical and chemical instruments, which, by a trifling sensible change, the displacement of a needle, the alteration of a colour, bring

within the range of our senses, decompositions of substances, or variations of currents, to which our senses cannot otherwise attain. The sudden reddening of a stained paper or the greater or less twist of a suspended needle are connected with an inner change or a certain degree of hidden action, and we observe the second things to which we cannot directly attain, in the first to which we do attain. —And similarly, when we are dealing with a general quality of which we can have neither experience nor sensible representation, we substitute, and substitute legitimately, a name for the impossible representation. It has the same affinities and repugnances as the representation, the same hindrances to and conditions of existence, the same extent and limits of presence; affinities and repugnances, hindrances and conditions of being, extent and limits of presence, all we meet in the one we meet, indirectly, in the other.—Owing to this correspondence, the general characters of things are brought within range of our experience; for the names expressing them are, themselves, either small experiences of sight, the ear, the vocal muscles, or internal images, that is to say, revivals more or less clear, of these experiences. An extraordinary difficulty has been surmounted; with beings whose life is but one varied and continuous experience, special and complex impressions can alone be found; out of these special and complex impressions nature has manufactured the equivalents of others, which are neither special nor complex, and which, as they cannot be so, would seem as if they must escape for ever by necessity and nature from beings constituted as we are.

V. The formation of these general names may be narrowly watched; with little children, we take them in the act. We name to them such and such a particular determined object, and, with an instinct of imitation common to them with monkeys and parrots, they repeat the name they have just heard.—Up to this point they are but as monkeys and parrots; but here there appears a delicacy of impression which is special to man. We pronounce the word *papa* before a child in its cradle, at the same time pointing out

his father. After a little, he in his turn lisps the word, and we imagine that he understands it in the same sense that we do, or that his father's presence only will reeal the word. Not at all. When another person—that is, one similar in appearance, with a long coat, a beard, and loud voice—enters the room, he calls him also papa. The name was an individual one; he has made it general. In our case, it is applicable to one person only; in his, to a class. In other words, a certain *tendency*, corresponding to what there is in common to all persons in long coats, with beards and loud voices, is aroused in him in consequence of the experiences by which he has perceived them. This tendency is not what you were attempting to excite; it springs up spontaneously. In it we have the faculty of language. It is wholly founded on the consecutive tendencies which survive the experience of similar individuals, and corresponds precisely to what they have in common.

We see these tendencies continually at work in children, and leading to results differing from ordinary language; so that we are obliged to correct their spontaneous and too hasty attempts.—A little girl, two years and a half old, had a blessed medal hung at her neck. She had been told, "*C'est le bon Dieu,*" and she repeated, "*C'est le bo Du.*" One day, on her uncle's knee, she took his eyeglass, and said, "*C'est le bo Du de mon oncle.*" It is plain that she had involuntarily and naturally constructed a class of objects for which we have no name; that of small round objects, with a handle, through which a hole is pierced, and hung round the neck by a ribaud; that a distinct tendency, corresponding to these four general characters, and which we do not experience, was formed and acting in her.—A year afterwards, the same child, who was being asked the names of different parts of the face, said, after a little hesitation, on touching her eyelids, "These are the eye-curtains."—A little boy, a year old, had travelled a good deal by railway. The engine, with its hissing sound and smoke, and the great noise of the train, struck his attention, and

the first word he learned to pronounce was *fafer* (*chemin de fer*). Henceforward, a steamboat, a coffee-pot with spirit-lamp—everything that hissed or smoked, or made a noise, was a *fafer*. Another instrument to which children have a great objection (excuse the detail and the word—I mean a *clysopompe*) had, naturally enough, made a strong impression on him. He had termed it, from its noise, a *zizi*. Till he was two years and a half old, all long, hollow, slender objects—a scissors-sheath, a cigar-tube, a trumpet, were for him *zizi*, and he treated them all with distrust. These two reigning ideas, the *zizi* and the *fafer*, were two cardinal points of his intelligence, and from them he set out to comprehend and name other things.

In this respect the language of children is as instructive to a psychologist as the embryonic states of organized bodies are to the naturalist. Their language, unlike ours, is living, and incessantly on the change; not only are words defaced or invented, but, more than this, the sense of words is not the same as in our language. A child who pronounces a name for the first time never takes it in the precise sense which we give it. This sense is more or less extensive to him than to us; it is proportioned to his experience at the time; is enlarged or reduced daily by his new experience, and brought very slowly down to the precise dimensions which it has for us.*—A little girl, of eighteen months old, had been heartily amused by her mother, or nurse, hiding in play behind the door or chair, and saying, "*Coucou.*" Again, when her dinner was too hot; when she went too near the fire; when she put out her hand to the candle; when they put on her hat in the garden, to keep off the hot sun, she was told "*Ca brûle.*" Here were two remarkable words which, to her, represented things of supreme

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* An analogous difference appears in comparing the synonyms in two languages: *clergyman* and *ecclésiastique*, *God* and *Dieu*, *liebe* and *amour*, *brio* and *brillant*, *girl* and *jeune fille*, do not respectively mean the same things, though we translate one by the other. The two words of each couple represent two different objects, and are differently understood by the two peoples. Their sense is the same in the rough; the details of their meanings are different and untranslatable in the absence of similar objects and emotions in the two cases.

importance; her most painful sensation and her most pleasurable one. One day, seeing from a terrace the sun disappearing behind a hill, she said, *"A bûle coucou."* Here we have a complete judgment, not only expressed by words which we do not employ, but also corresponding to ideas, consequently to classes of objects, to general characters, to distinct tendencies, which in our cases have disappeared. The hot soup, the fire on the hearth, the flame of the candle, the noonday heat in the garden, and last of all, the sun, make up one of these classes. The figure of the nurse or mother disappearing behind a piece of furniture, the sun disappearing behind a hill, form the other class. Both are limited to this; the tendency consecutive to the first resulted in the words *a bûle;* the tendency consecutive to the second in the word *coucou.*—Such a state of mind differs greatly from ours; but, nevertheless, it consists of tendencies analogous to ours, aroused in the same way as ours, corresponding to general characters as with us, but to characters less general, in short, resulting in names similar in sound and different in sense.

In proportion as the experience of children approaches more nearly to our own, their tendencies to name coincide more exactly with ours; they become organized by degrees like embryos. As in the fœtus, we see, in turn, the disproportionate head reduced to its proper proportions, the sutures of the skull harden, the cartilage turn into bone, the rudimentary vessels close and ramify, the communication between child and mother become obstructed; so do we see, in the language of children, the two or three dominant words lose their absolute preponderance, the general words limit their too extensive meaning, gain precision for their vagueness of sense, acquire connections, attachments and sutures with each other, become complete by the incorporation of other tendencies, become arranged under these into names of smaller classes, form a system corresponding to the order of beings, and at last act by themselves alone, and of themselves, without the aid of assisting namegivers.—A child has watched its mother put on her white dress for a

ball; he has remembered the word, and in future, when he meets a lady in evening dress, whether she has on red or blue, he will say in his singing, curious, happy voice, "*You have put on your white dress.*" *White* is too large a word; he will have for the future to reduce its application to a single colour.—The same child hears his mother say to him, "You swing your head too much; it will strike the table." He says, in a curious and surprised way, "*Your head will strike the table?*" *Your* again has received too large a sense; he must be taught to reduce it to mean the head only of the person he is speaking to.—The process of checking goes on; new experiences will complete the tendency which produced the word *white*, and once accomplished, it will correspond not only to the presence of bright fresh colour, but, more than this, to the presence of a particular colour. Similarly, and by another series of experiences, the *tendency* which produced the word *your* when given definite precision, will correspond not only to possession, but also to this supplementary circumstance, that the thing possessed belongs to the person spoken to. Such is the history of language: we experience spontaneously, after having come in contact with a series of similar objects, a tendency which corresponds to what there is in common to these objects; that is to say, to some general character, to some abstract quality, to an extract from the objects, and this tendency results in a gesture, in some mimicry, in some distinct sign, which in maturity becomes a name.

Herein consists the superiority of the human intelligence. Very general characters arouse in it distinct tendencies; in other words, very slight resemblances between different objects are sufficient to excite in us a name or special designation; a child succeeds here without effort, and the genius of well-endowed races, as that of great men, and notably of inventors, consists in observing resemblances more or less delicate and novel; that is, in feeling arise in them, at the sight of objects, certain slight and delicate tendencies, and consequently, distinct names, which correspond to shades imperceptible to ordinary minds, to the very

slight characters hidden beneath a heap of the coarse, striking circumstances, alone capable, when the mind is ordinary, of leaving an impression upon it, and having a response in it.—This aptitude once established, the rest follows. By the accumulation and contrariety of daily experiences, tendencies and names multiply, are circumscribed, and become subordinated, like the general qualities they represent; and the hierarchy of things is translated and repeated within us by the hierarchy of tendencies and names.

VI. On the other hand, if we may use the expression, names fill out. In proportion as our experiences become more numerous, we remark and consequently name a greater number of general characters in the same object. Its name, which at first denoted the single character which struck us at first sight, now denotes several others. It now corresponds, not to an abstract quality, but to a group of abstract qualities; it was only general, it becomes *collective.*

Take any animal, a cat, for instance. As all cats have points of strong resemblance, and differ a good deal from our other animals, we have no difficulty in learning their common name, and observing their common characteristics. In other words, this name corresponds to a certain distinct form, at rest or moving, sleeping in a stable, or creeping cautiously along a roof. This is the common popular sense, and the tendency which results in the name corresponds to little more than this.—But a naturalist takes me, and opening a cat, shows me the pouch we call the stomach, the little vessels we call veins and arteries, with their infinite ramifications; the collection of smooth tubes which are the intestines, and the bars, arches, frames, cavities, and hinges, which, with their connections, make up the skeleton.—I might remain for six months continually seeing new things. If I were to work with a microscope, my life would not be long enough, and, speaking accurately, no life or series of lives would suffice; beyond the observed properties, there will always remain others unobserved, the unlimited matter of

an unlimited seienee. Henceforward the name corresponds for me, not merely to the experienee of a certain external form, but also to that of a eertain internal strueture, that is, to an enormous number of various phenomena whieh I have experieneed, and to an indefinite number whieh I might experienee. If I have paid sufficient attention to the internal structure, I shall pronounee the word cat as confidently when I see the blaneheđ skeleton, as at the sight of the living furry body. The second expcrienee now results in the same name as the first. Two distinet tendeneies eoineide therefore in the same effeet. The name has beeome the equivalent of the eharaeters eommon to the different skeletons of the kind, as of the eharaeters eommon to the differcnt living animals of the kind; its presenee, whieh onee aroused images only of eertain velvety, living, bounding forms, now arouses also images of eertain bony lifeless frameworks.—It may arouse many other images, those of all the mechanical, physical, ehemieal, anatomieal, vital, moral peculiarities whieh naturalists and moralists ean diseover in the raee of cats; it assembles them all in itself, together with the names we denote them by; it is the substitute of the whole band. On hearing the name eat, we ean substitute for it a definition or a description—that is to say, replaee it either by the two principal names whieh determine its rank in the elassifieation of animals, or by the names of all the charaeters which our experienees have diseovered in it, and eonsequently, reeal more or less vividly to our minds, the likenesses of sueh experienees. Henceforth, the eouple whose first term is the name, eomprises, as seeond term, an immense list of other words, and eonsequently, as great a series of distinet tendeneies, whieh eorrespond to general eharacters equally distinet, and leave room beside them for an infinite number of new tendencies whieh experienee may exeite.—Sueh is the power of the substitution established by eouples. Two terms being the equivalents of one another, the first, whieh is so simple, so manageable, so easy to reeal, is capable of replaeing the seeond, even when the seeond is an immense

army, whose lists always open, await and are continually receiving new soldiers.

The reader sees at once that in place of the name cat we might put that of dog, monkey, crab, or of any animal or plant whatever; or again, that of any group, animal or vegetable, as extensive or as narrow as we please, and, in general, of any group, moral or physical. The operation would be similar; all general names acquire extensions of meaning in the same way.—Arranged in relation to one another, each with its retinue of tendencies, they make up the principal furniture of a thinking brain. By the side of continual experiences and reviving images, there are names which we term ideas; all of them mental representatives of abstract characters and general qualities, each one called up by some distinct tendency, all incessantly extended by new tendencies, gaining precision in their application, and increased in their contents by the daily progress of discovery, which, adding to their meanings, limits their application.

CHAPTER III.

OF GENERAL IDEAS AND REPEATED SUBSTITUTIONS.

I. THERE are things of which we can have no experience; now, since experiences are what, by their common character, arouse in us a distinct tendency and the name which we term an idea, it seems as if we could never attain to ideas of such things. We have, nevertheless, very clear and exact ideas of them. The operation, which consists in giving names to things, becomes complicated, and leads us by a circuit to unhoped-for successes. The same instrument is at work as before, but it works by a series of substitutions, instead of a simple substitution.

Consider the first number that comes to hand: 36, for example. When I read this sign, I thoroughly understand its sense; that is, I clearly imagine what it replaces. 36 is by definition 35 *plus* 1. In other words, the group we call 36 is the same as that which we call 35, if to 35 we add 1. 36, then, is a collective term which replaces two others. But 35, by definition, is 34 *plus* 1; 34, again, is 33 *plus* 1; and so on. 36, then, in final analysis, is an abbreviatory expression which replaces thirty-six others. Let us go back to the elements, the better to understand this operation.

Suppose a red counter at one corner of the table, and a white one at another. I may neglect all their respective qualities, and be struck solely with the fact that a part of my impression is *repeated*, and feel that what I have just experienced in the case of the red counter is, up to a certain point, similar to what has happened in the case of the white, and after the two several experiences, may feel a

distinct consecutive tendency, corresponding to their number, that is, to the property they have of being two.—This, like all other tendencies, results in a sign; let us take for this sign the ordinary word, two. Here is a general name; we shall be inclined to pronounce it, as in the case of the counters, after each *repeated* experience. Similarly, too, when we read it or hear it, we have only to dwell on it to call up inwardly, as with the word cat or birch-tree, an image of a case to which it is applicable; we think of a counter beside a counter, a stone beside a stone, a sound followed by a sound, as just now we imagined a tapering face with white or grey fur, a slender white trunk with small quivering leaves.—The same is the case with the words, three, four; it is more difficult with the words, five, six; the difficulty increases with the higher numbers, and there is always a figure, larger or smaller, at which the mind stops; we cannot perceive or represent distinctly to ourselves as a whole, more than a certain number of facts or objects; generally five or six, more often four.—To remedy this inconvenience we neglect the group corresponding to the word, and fix our whole attention on the word we have substituted for it; after seeing four objects together we forget them, and think only of the word four, and this is allowable, since when later on we return to the word and consider it, we shall see the objects again in our minds without mistake or confusion. Here then we have four operations replaced by one only.—When a new object, similar to the foregoing ones, is met with after we have pronounced the word four, it will form, with the word, a new group, and will excite in us a tendency analogous to that which made us use the word two—a tendency similar to the first from its involving an addition, differing from the first from its being an addition, not of one object to another, but of an object to a group of four objects. This new tendency results in a new name, five. Another, excited by this previous one, will result in the word six, and so on.—We see that in this scale each new name is the substitute of the preceding one,—and

consequently of the object of the preceding one—joined to unity.

Here, again, an insurmountable difficulty has been evaded. If we can imagine distinctly as a whole two, three, or even four objects, we cannot do so with respect to 36 as a whole. The abstract and general property of being two, three, or four, may arouse in us a tendency, and consequently a corresponding name; on the other hand, the general and abstract property of being 36, or any other considerable number, cannot do this.—Before an obstacle like this we must proceed indirectly; we bridge over the ditch too wide for our legs. We no longer replace at once by a word the general and abstract character of the group in question; for experience cannot successfully attain to such a group. Thirty-six pawns on a chess-board give an impression only of a mass and a whole, without distinct numerical knowledge of the individuals.—We proceed more slowly; we first take a very small group, proportioned to the limited range of our minds, and capable of arousing in us a tendency and a name. We next join this name, and consequently the object of the name, that is, the little group, to a new individual, and this arouses in us another tendency and another name; and thus step by step we journey on to the final name, and this once obtained, corresponds to the abstract character which did not directly arouse a name.

In this respect the final name is very remarkable. If we look for its sense we find a name only, that of the lower figure to which we add unity; the same thing happens with this lower figure, and so on; it is only at the end of this retracement of our steps, when we have descended some 30, 50, 100, 1000, or 10,000 stories, that we arrive again at our experience.—And yet this name *replaces* an experience, another experience which we have not attained, which we cannot attain, which is above man's powers, but which is in itself possible, and which a more comprehensive mind might attain to: 36 denotes the quality common to all groups of 36 individuals; a quality which, as presented to

us, does not excite any precise tendency, and which a mind capable of representing before it at once 36 objects or facts in a distinct state, would alone experience. By this artifice, we attain the same results as creatures endowed with imaginations and memories far more clear and vast than our own. Here, as before, all has been effected by substitution. After having enabled us to arrive at abstract qualities, she affords us the means of counting and measuring quantities. Thanks to substitutions, we were enabled to conceive the abstract qualities of individuals. Thanks to a series of repeated substitutions, we are able to name, and consequently to conceive, certain abstract properties peculiar to groups—properties which the natural limitation of our imagination and memory seemed to hinder us from ever conceiving, that is to say, from naming.

II. The efficiency of substitution extends far beyond this. —As the reader knows, geometrical objects do not exist in nature. We do not meet, and probably can never meet, with perfect circles, cubes, and spheres. Those we see or construct are but approximately so.—Nevertheless, we conceive them as perfect; we reason about figures of absolute regularity. We know, with complete certainty, what is the obtuseness of each angle in a regular myriagon, and to how many right angles the whole of its angles taken together amount. Besides this, when for the better apprehension of a geometrical theorem we construct a diagram on paper, we trouble ourselves very little as to its perfect proportions; we admit without difficulty shaky lines in our polygon, and irregular curvature in our circle. In fact, we do not consider the circle traced on the paper; it is not the object, but the aid of our thought; by its means we conceive something differing from it, which is neither black nor traced on a white ground, nor of any particular radius, nor of unequal curvature.—What, then, is this object we conceive, and of which experience affords us no model? The definition tells us. A circle is a closed curve, all whose points are equally distant from an internal point called the centre.—But what have we in this phrase? Nothing,

except a series of abstract words which denote the genus of the figure, and another series of abstract words which denote the species of the figure, the second being combined with the first, as a condition added to a condition. In other terms, an abstract character denoted by the first words has been joined to an abstract character denoted by the second words, and the total compound thus constructed denotes a new thing to which our senses cannot attain, which our experience cannot come in contact with, which our imagination cannot trace. There is no necessity for our attaining to, meeting with, or imagining this thing; we have its formula, and that is enough.

In fact, this formula would be rigorously the same if the object had fallen within our experience. We have constructed the formula before instead of after the experience, and it corresponds all the more closely to the thing, since the thing must bend to it—not it to the thing. The two then make up a couple whose second term, the definition, is equivalent to the first term, that is, to the object. —This object may remain ideal: it may itself be situated beyond our grasp; it matters little; we have its representative. Whatever properties and relations we find in the substitute we shall safely ascribe to the thing for which it is substituted. We arrive at this indirectly, as a surveyor, who, wishing to measure an inaccessible line, measures a base and two angles, and knows the first quantity by the three second.—In this way all mathematical conceptions are formed. We take very simple abstractions, the surface which is the limit of the solid, the line which is the limit of the surface, the point which is the limit of the line, the unit or quality of being one, that is to say, distinct existence among similar things. We combine these terms together and form, first, compounds of small complexity, those of two, three, four, and the earlier numbers, those of plus and minus, of greater and less, of longer and shorter lines; then those of straight line and curve, of triangle, of circle; then, those of sphere, cone, cylinder, and the rest. The complication of compounds goes on increasing; it is un-

limited. Taken together they form a kingdom apart of objects which have no real existence, but which are capable, like real objects, of being classed in families, genera, species, and properties, of which we discover by considering in their place the properties of the formulæ which we substitute for them.

By a strange continuation the process which has formed these objects is also that which establishes their relations. Arithmetic, algebra, geometry, analytical geometry, mechanics, the higher calculus, all the propositions of mathematical science, are substitutions. Any number we take is a substitute for the preceding number added to unity. To calculate, is to replace several numbers by a single one at the end of several partial replacements. To solve an equation, is to substitute terms for other terms with the object of arriving at a final substitution. To measure, is to replace an undetermined magnitude by another magnitude defined in its relation to unity. To construct a diagram for the demonstration of a theorem is to substitute certain known lines and angles for other lines and angles which it is required to know. To find the algebraic formula of a curve, is to discover a mathematical relation between certain lines which are connected with the curve, and to translate quality into quantity.—However we may reason about numbers and magnitudes, the process amounts to passing from one equivalent to another equivalent by the aid of a series of intermediate equivalents, to replacing magnitudes by numbers expressing them, a figure by a corresponding equation, a complete quantity by a quantity in process of completion, having the first as limit, movements and forces by lines representing them. We pass from each province to the other by substitutions, and, as a substitute may have substitutes, the operation has no limits.

III. Leaving for the moment this extension of our process, let us consider it once more at its outset. We have seen how, by combining abstracts, we construct the first terms of couples, the second terms of which are beyond our reach,

and how, by the study of the generating formula, we discover the properties of the object engendered by it. In certain cases, we discover in it wonderful properties, and the formula makes known to us facts situated not only beyond our experience, but beyond all experience.—If we divide 2 by 3, we find an infinite decimal fraction, 0·6666 &c., and we can prove that it is infinite. It is strictly so, and without possible break; however far we may prolong the operation, the remainder will always be 2 and the quotient always 6. After a million, after a thousand million, after a million million of such divisions, new terms will present themselves, with the same remainder and the same quotient, with a total quotient always too small, too small by a fraction with 2 for numerator, and for denominator unity followed by as many zeros as there are units in the number of divisions we have made. Here is something infinite; not vague, not indefinite, but precise, which is expressly opposed to any limit, and so clearly conceived that all its elements have their distinct and express properties.—Does this mean that I perceive distinctly the infinite series of these elements? Certainly not. Here again, there is a substitute, the formula, from which the series and the properties of its elements are derived. What we perceive, is a general character of the dividend and remainder. After the first division we can see that, the remainder being 2 like the dividend, must, in becoming in its turn a dividend, give rise again to a remainder 2, which in its turn will do the same, and so on. In other words, we discover in the dividend this property of giving rise to a similar figure, which, being similar to it, has the same property as it. This abstract quality is the cause of the whole series; it forces it to be infinite, it alone is what we perceive; when we say that we conceive an infinite series, it only means that we discover this property of inexhaustible regeneration; all we seize is the generating law; we do not embrace all the engendered terms.—But as far as we are concerned the effect is the same; for by applying the law we are able to define whatever term we

please of the series, to measure exactly the increase of approximation it brings to the quotient, to calculate strictly the degree of error which the division would include were we to stop here. The perception of the law is equivalent to the perception of the series; an infinite line of distinct terms finds its substitute in an abstract character, and, in place of an experience which is by definition impossible, we have disengaged a property whose isolation has only required two experiences, and which is of equal value to us.

And so it happens, whenever we conceive and affirm some really infinite abstract magnitude, time, or space. We take a fragment, some short portion of the duration comprised in our successive sensations, some narrow portion of space comprised in our simultaneous sensations. We consider this fragment apart; we extract from it this property it has of being over-extended by a border absolutely similar to itself. We lay down, as before, a general law that the magnitude in question is continued beyond itself by another wholly similar magnitude, and this by another, and so on, without the possible intervention of a limit. Our conception of infinite time and infinite space is reduced to this.—But the result is the same as if the field of our imagination were infinitely extended and capable of setting before us at a glance the whole infinite succession we call time, or the extension, infinite in three directions, which we call space. For starting from the general character which alone is present to our minds, we are able to imagine any portion of time or space as clearly, and to affirm of it as surely, as if we had experience of it; no matter what the portion be, whether a fragment of duration preceding the solar system, or a portion of space beyond the furthest nebulæ of Herschel. It is possible, then, to represent infinite objects, series, or quantities,* by an abstract property. It is enough if this is their generator. By it, indirectly, they become present. Here we have, I think, the most

* When we speak of an infinite quantity, it is by extension; strictly speaking, a quantity is always finite, and there is nothing infinite but *series*.

extraordinary example of substitution.—There are other cases, analogous but reversed, in mathematics; certain quantities, which go on increasing or decreasing, without the possibility of a limit, replace the limit which they necessarily approach without ever touching it. A polygon with an infinite number of sides inscribed in a circle is equivalent to the circle. The fractional number $1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}$ &c., is equivalent to the number 2. Here again, as before, mathematicians do but resume, extend, or reverse a spontaneous process of the mind.—The process is explainable similarly, whether direct or reversed. Given two members of a couple, one infinite, the other limited, we can consider at will the one or the other, and if they correspond strictly, can discover in the one properties belonging also to the other, but not discoverable in it.

IV. To recapitulate. We do not conceive numbers, with the exception of the three or four earlier ones, but their equivalents, that is to say, the name of the preceding number joined to unity; we do not conceive infinite or ideal objects, but the abstract characters which generate them; we do not conceive abstract characters, but the common names which correspond to them. However far we may go, we always come back to names. Things the most removed from our experience and the most inaccessible to all experience, seem present to us; what is actually present, in such a case, is a name, the substitute of an abstract character which is itself the substitute of the thing, and this often only through many intermediate stages, till at last by a series of equivalents the chain re-touches the distant object which we cannot directly reach.

Hence arise singular illusions. We believe that, in addition to our general words, we possess general ideas; we distinguish the idea from the word; it seems to us something apart from the word, and to which the word is merely auxiliary; we compare it with the image, and pronounce them to fulfil similar offices in distinct provinces, and that ideas bring present to us general things, as images bring present individuals. We remark with

Descartes, that we can readily conceive a myriagon but have great difficulty in imagining it. We set on one side the intelligible myriagon and the corresponding precise idea, and, in contrast, the actual myriagon and the corresponding confused image. We then observe that this idea is in no way similar to the image, except in its employment; it brings before us an absent thing as the image does, but that is all. It has no other properties: it is not, like the image, an *echo*, the echo of a sound, a smell, a colour, a muscular impression, in short, the internal revival of some sensation; there is nothing sensible about it, and we can only define it by denying of it all sensible qualities; it seems then a pure activity stripped of all other qualities but that of bringing the myriagon present to our minds. We compare it to something intangible, unextended, incorporeal; we suppose a being as pure and ethereal as itself of which it is the manifestation; we call it mind, and say that, irrespective of images, our mind knows and deals with abstract qualities of things.

The mechanism of this illusion may now be readily detected. We have overlooked the word which is the whole substance of our operation; we have treated it as accessory and have considered the operation, omitting what it comprises; hence a blank.—This error of consciousness is of frequent occurrence and may be traced to a general law. When an impression, or group of impressions, is many times repeated, our attention ends by fixing itself entirely on the interesting and useful part; we neglect the rest, we cease to notice it, we become unconscious of it, and though present, it seems to be absent. So it is, for instance, with the slight muscular sensations occasioned by the eye adapting itself to various distances; they are the signs of these distances, and by them we determine the degree of proximity or distance of objects. We necessarily have these sensations when we judge of distances, but we cannot detect them, even if we wish to. To us, they are as if they did not exist; we appear to know directly, and without their aid, the positions which they alone denote; if ever they

strike us, it is in extreme cases, as when we attempt to read something at a distance, or inconveniently near the eye, and feel sensible fatigue in the muscles; except in such cases they are invisible, and have, as it were, vanished.—So again, a composer who has just read some air of an opera, does not recall the crotchets, quavers, keys, staves, and all the black hieroglyphics over which his eyes have passed, but only the series of chords which he has heard mentally; the signs are obliterated, the sounds alone survive.—When words are in question, we can trace the different degrees of this obliteration. The meaning of a page in manuscript is comprehended with far more difficulty than that of a printed one; our attention is partly attracted by the external form of the characters, in place of attaching itself solely to the sense they bear; we observe the individual peculiarities of the signs, as well as what they are employed to represent. But after a while, these peculiarities cease to strike us; when they are no longer new, they are no longer singular, and no longer singular, are no longer observed; and then, in the manuscript as in print, we seem no longer to be following words, but pure ideas.—We see now how it necessarily happens, that in our reasonings, and all the higher operations of the mind, the word, though present, is unperceived. From the train of our discoveries we conclude that we have acted, and produced a series of acts, that this series corresponds to a series of qualities, or characters of things, that our activity is effective, and therefore real. What then can we affirm of this internal activity? Nothing, except that it is activity; by the disappearance of words we have exhausted it of all it comprises; we set it apart pure and simple, or as we say, spiritual; having stripped it, we believe it to be naked; and when, later on, we observe that to produce it we have made use of signs, we conclude that the sign is but a preliminary aid to it, and a distinct reminder of it. This separation and nudity are of our own effecting; they do not belong to it, but are lent it by us.

This is the first of psychological illusions, and what we

term consciousness swarms with such. The false theories they have given rise to are as complex as they are many, and are at present obstructing science. When they are cleared away, science will become simple again.—Having discarded this illusion, we see the consequences. What we have in our minds when we conceive general qualities and characters of things, are signs and signs only. I mean certain images or revivals of sensations of the eye or ear, wholly similar to other images, except in their corresponding to characters and general qualities of things, and in their replacing the absent or impossible perception of these characters and qualities.—Thus when, neglecting present sensations, we observe the never-resting inmates of our mind, we find there images only, some prominent ones which strike the attention, others faded, and seemingly worn away to shadows, on account of the attention being diverted from them to their uses. Here we have an element of knowledge which seemed primitive, but which is reduced to another. We must now attempt to know that other. Since our ideas may be reduced to images, their laws may be reduced to laws of images; images then are what we must study.

BOOK II.

OF IMAGES.

CHAPTER I.

OF THE NATURE AND REDUCTION OF IMAGES.

I. Yesterday evening,* about five, I was on the quay by the Arsenal, watching in front of me, across the Seine, the sky reddened by the setting sun. Fleecy clouds rose in the form of a half dome, and bent over the trees of the Jardin des Plantes. The whole of this vault seemed encrusted with scales of copper; countless indentations, some almost burning, some nearly black, extended, in rows of strange metallic lustre, up to the highest part of the sky, while, all below, a long bronze-coloured band, extending along the horizon, was streaked and cut by a black fringe of branches. Here and there, rose-coloured gleams of light rested on the pavements; the river shone softly through a rising mist; I could see barges floating with the stream, and two or three teams of horses on the bank, while towards the east, the slanting beams of a crane stood out against the grey sky. In half an hour, all this had died out; there was but one patch of clear sky behind the Pantheon; reddish-coloured smoke was wreathing about in the dying purple of the evening, and the vague colours intermingled. A blue vapour hid the arches of the bridges and the edges of the roofs. The apse of the cathedral stood alone, looking with its pinnacles and jointed buttresses, in size and shape like an empty crab-shell. Things prominent and coloured but

* 24th November, 1867.

a moment ago, were now like mere sketches on a dull paper. Here and there a gas-light shone out like a lonely star, and caught the attention as other things faded away. Soon, strings of light extended themselves as far as the eye could reach, and the indistinct flickering glare of crowded Paris rose in the west; while below the arches, along the quays, and over the weirs, the rippling water kept up its nightly murmuring.

I saw this yesterday; and now as I write I see it again—dimly, it is true, but still I see it. The colours, forms, sounds, which struck me yesterday, are now renewed, or nearly so. Yesterday, I experienced sensations excited by the immediate contact of things and immediate action of the nerves. To-day, impressions analogous to those sensations, though remotely so, arise in me, notwithstanding the want of this action and contact, notwithstanding the presence of other actions and contacts. It is a semi-revival of my experience; different terms might be used to express it, we might call it an after-taste, an echo, a representation, a phantom, an *image* of the primitive sensation; it matters little; all these comparisons mean no more than that after a sensation excited by the outer world, and not spontaneous, we find within us a second event corresponding to it, which is spontaneous and is not excited by the outer world, which resembles the sensation, and is accompanied, though not so forcibly, with the same emotions, which is pleasurable or the reverse, but in a less degree, and is followed by some, but not all, the same mental conclusions. The sensation repeats itself, though with less distinctness and force, and deprived of many of its surroundings.

This obliteration is more or less complete according to the differences of men's minds, and this is what we mean when we say that men have more or less memory. Again, it is more or less complete in the same minds according to the different kinds of sensations, and this is what is meant by saying that such a man remembers forms, another colours, another sounds.—For example, in my own case, I have but

an ordinary memory for forms and a slightly better one for colours. I can see without difficulty after several years five or six fragments of an object, but not its precise and complete outline; I can recall more easily the whiteness of a sandy path at Fontainebleau, the hundred little spots and stripes made by the sprigs of wood strewed on it, its winding curves, the faintly rose-coloured tints of the heather by its sides, the wretched appearance of a stunted birch clinging to the side of a rock; but I cannot trace in my mind the winding of the path or the jutting out of the rocks: if I mentally catch sight of the swelling of some vegetable muscle my half-sight stops there; above, below, all is vague; even involuntary revivals, which are the most vivid, are only half clear to me; the most visible and most highly coloured fragment is dull and tame. Compared to the sensation it is as a half-heard whisper to an articulate, ringing voice. In my case, all that is reproduced uninjured and whole is the precise shade of emotion, harsh, tender, strange, sweet, or sad, which followed or accompanied the external corporeal sensation. I can thus renew my pains and pleasures, the most complex and most delicate, with extreme exactness and after considerable distances of time. In this respect, the incomplete and failing whisper has almost the same effect as the voice.—But if, instead of taking the instance of a man inclined to pay principal attention to sentiments, we look at men accustomed to observe particular colours and forms, we shall find cases of images so clear as to differ little from sensations.

For example, children accustomed to calculate in their heads, write mentally with chalk on an imaginary board the figures in question, then all their partial operations, then the final sum, so that they see internally the different lines of white figures with which they are concerned. The remarkable children who are precocious mathematicians give a similar account of themselves.* Young Colborn, who had never been at school, and did not know how to read or

* Gall, "Fonctions du Cerveau," tome v. 130.

write, said that when making his calculations, "he saw them clearly before him." Another said that he "saw the numbers he was working with as if they had been written on a slate."—So again, we find chess-players who play a game with their eyes closed, and faces turned towards the wall. They have numbered the squares and pieces; at each move of their opponent they are told the piece moved and the new square it occupies; they give directions themselves for the movement of their own pieces, and go on in this way for many hours. They often win, even when opposed to skilful players. Evidently the figure of the whole chess-board, with the different pieces in order, presents itself to them at each move, as in an internal mirror, for without this they would be unable to foresee the probable consequences of their adversary's and their own moves.

An American friend of mine, who has this faculty, describes it to me in these words: "When I am in my corner, facing the wall, I see simultaneously the chess-board and all the pieces, as they were in reality after the last move. And as each piece is moved, I see the whole chess-board with the new change effected. If I am in doubt in my mind as to the exact position of a piece, I play over, mentally, the whole game from the beginning, attending carefully to the successive movements of that piece. It is far easier to deceive me when I watch the board than otherwise; in fact, when I am in my corner, I defy any one to mislead me as to the position of a piece without my afterwards detecting it. . . . . I see the piece, the square, and the colour, *exactly* as the workman made them—that is, I see the chess-board standing before my adversary, or at all events, I have an exact representation of it, and not that of another chess-board. So far is this the case that, before retiring to the corner, I begin by carefully looking at the chess-board and men as they stand, and to this first impression I mentally attend and revert." Usually, he does not see the table-cloth nor the shadows of the pieces, nor the minute peculiarities of their make, but can recall them if he

wishes. He has often played chess with a friend who has also this faculty, while walking along the quays or in the streets.—As might be expected, so exact and intense a representation is repeated and lasts involuntarily. "I have never played a game," says he, "without having played it over again four or five times in the night in bed, with my head on the pillow. . . . . When I am sleepless and have unpleasant thoughts, I set myself to play at chess, imagining a game, with all the pieces, and this occupies my mind and drives away the besetting thoughts."—The first players are not the most skilful at this artifice. Labourdonnais could only play two games at once, mentally; having once attempted three at a time he died from the effort. "It is not unusual to find in clubs, fourth-rate players who wake up some morning with this faculty."—Some of them attain an extent and clearness of imagination which are simply marvellous. "Paul Morphy plays eight games at a time, and Paulsens twenty. This I have seen myself."—Other images, far more irregular and with more variety of shade, and so, it would seem, more difficult to recall, present themselves with equal precision. Certain painters, draughtsmen, and sculptors, after attentively considering a figure, are able to draw it from memory. Gustave Doré has this faculty; Horace Vernet had it. Abercrombie* mentions a painter who copied from recollection and without the aid of an engraving, a Martyrdom of Saint Peter, by Rubens, with so perfect an imitation that the two pictures, being placed beside one another, considerable attention was required to distinguish the copy from the original.

We can follow the different stages by which the ordinary image passes to this height of clearness and detail. In a school of art at Paris, the pupils were practised in copying models from memory. After four months' practice they said that "the image" had become "much more distinct,

* "Inquiries concerning the Intellectual Powers," p. 126; and see Brierre de Boismont, "Des Hallucinations," pp. 449 et seq., 26 et seq., where many analogous cases are collected. See also "Annales Médico-Psychologiques," 3me Série. ii. 295

and if it disappears they can recall it almost at will."—M. Brierre de Boismont,* having studiously impressed on his mind the figure of a priest of his acquaintance, says, "At present this mental representation is visible to me, whether my eyes be shut or open." The image appeared to him "external," placed in front of him "in the direction of the visual ray. . . . . It has the size and characters of the original; I can distinguish his features, the cut of his hair, the expression of his face, his dress, and all the details of his person. I see him smile, speak, preach; I mark even his habitual gestures . . . . . The image is shadowy and of a different nature from the objective sensation . . . . . but clearly outlined and coloured," and, saving this distinction of nature, provided with all the characters belonging to the real person, or, more precisely, with all the characters which belong to the sensation experienced in the presence of the real person.—We may confidently assert then, that the internal event, which we call a sensation, and which is produced in us when our nerves, and consequently our brain, receive an impression from without, is reproduced in us without impression from without—in the majority of cases partially, feebly, and vaguely, but in many cases with greater clearness and force; in some cases with a precision and detail nearly equivalent to what we find in the sensation.

The sensations of hearing, of taste, of smell, of touch, and, in general, all sensations, whatever be the nerve by whose action they are excited, have their images. We can all of us hear tunes mentally, and in some cases the image is not far removed from the sensation. Just now, thinking over a representation of the "*Prophète*," I repeated silently to myself the pastorale from the overture, and followed, I venture to say almost felt, not only the order of the notes, their different height, rests, and lengths, not only the musical phrase repeated as an echo, but also the keen, piercing tone of the hautboy which plays it; its

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* Op. cit. 449; and De Boisbaudran, "Education de la Mémoire Pittoresque," pp. 77 and 83.

sharp drawn-out notes of so rustic a harshness that the nerves are startled, and filled with a rough pleasure, as at the taste of raw wine.—Every good musician experiences this sensation at will, when he follows the lines of music covered with their black marks. The leader of an orchestra,* questioned by M. Buchez, told him that when he looked over a score "he heard as in his ear" not only the chords and their succession, but also the tone of the instruments. On the first reading over, he distinguished the quartet; at the second and succeeding ones, he added to the quartet the other instruments; and finally he perceived and appreciated distinctly the effect of the whole.—Great musicians have this gift of internal hearing in an eminent degree. It is well known that Mozart, having twice heard the *Miserere* of the Sistine Chapel, wrote it down entirely from memory. As it was forbidden to copy it, the fidelity of the master of the chapel was suspected, on account of the difficulty of the exploit.† Mozart, no doubt, on his return home, found in his mind, when seated at his table, as if in a minutely exact echo, these lamentations composed of so many parts and carried over a series of notes so strange and delicate. When Beethoven composed many of his great works after he had become completely deaf, the combinations of notes and tones which we now admire in them were present to him. They were necessarily present, since he measured their effect beforehand, and measured it with rigorous precision.

II. This close resemblance of the image and sensation becomes clearer still if we consider the circumstances under which the higher degrees of intensity of the image occur.—A first excitant is the extreme nearness of the sensation. When we have heard a full striking tone, for example, the rich prolonged note of the violoncello, clarionet, or horn, if the sound suddenly ceases, we continue for some seconds

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* Brierre de Boismont, op. cit. 459.

† It is necessary to have heard this *Miserere*, to appreciate the capacity and precision of such memory for music.

to hear it mentally; and, though at the end of these seconds its image becomes feeble and obscure, we continue, if we derived any pleasure from it, to repeat it internally with remarkable fidelity, and without letting go any portion scarcely of smooth or striking sound. And so, when we shut our eyes after having regarded attentively any object, a figure in a print, the back of a book in a library, the perception, which has become internal, continues for nearly a second, then disappears, then renews itself, but softened; then is troubled and fails utterly, without leaving any other trace than a vague outline; and the losses which the image has undergone prove by their contrast the force it had to commence with. So it is after a smell, a taste, an impression of cold, of heat, of local pain, and the rest.—If the sensation, instead of preceding, is about to follow, the effect is the same. A gourmand seated before a savoury dish, the steam of which is rising under his nose, and into which he has already put his fork, tastes beforehand its exquisite flavour, and the glands of his tongue become moistened; the image of the expected flavour is equivalent to the sensation of the actual flavour; the resemblance is carried so far that the salivary glands are equally excited in either case. This is why a physiologist, who wishes to obtain a quantity of saliva to experiment with, ties up a hungry dog a few inches from a piece of meat, and collects the liquid which the flavour continually wished for and continually absent discharges from the animal's jaws. So by an analogous but contrary effect, anything unpleasant we are obliged to take excites vomiting by the simple thought of its taste before it touches our lips. So again, a ticklish person whom we threaten to tickle, and who sees our hand approaching, imagines so strongly the coming sensation, that he has spasmodic feelings, the same feelings, in fact, as if the sensation had taken place. Many persons who are about to undergo a surgical operation, feel beforehand the shooting pain which will follow the first cut, and sweat and grow pale at the very thought, and sometimes suffer as keenly

as when under the saw and knife. A lady* who thought she was inhaling nitrous oxide, and who had simply a bottle of common atmospheric air under her nose, fell in a fainting fit. These examples show us also that the importance of the sensation is another excitant as powerful to strengthen the image as the proximity of the sensation. A traveller in Abyssinia† saw one of his men torn by a lion; many years afterwards, when he thought of the circumstance, he could hear mentally the cries of the unhappy man, "and felt as if a hot iron were entering his ear." Numbers of mystics‡ have represented to themselves the passion of our Lord with such force, that they have believed themselves to feel in their bodies the rending and pain of the Saviour's wounds.—Every one knows the power of an image, especially when strange and terrible, upon an excited and prepared mind: it is mistaken for a sensation, and the illusion is complete. Children, and even grown men, have fallen insensible before a figure, or even a cloth, which they have believed to be a ghost. On recovering, they have asserted that they saw flaming eyes, open jaws.—In all these cases the image has in no way differed, for the time at least, from the corresponding sensation, and it is only after the lapse of a longer or shorter time, when the recollection has subsided, and the circumstances have been looked into, that the deceived person has recognised his mistake.

III. Hitherto we have seen the image approximating to the sensation, acquiring the same clearness, the same abundance of minute and circumstantial detail, the same force, sometimes even the same persistence, furnishing the same foundation for higher combinations and ulterior reasonings, exciting the same impressions and same instinctive actions, organic and muscular, having in short the same properties, the same accompaniments, and same conse-

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* Mueller, "Elements of Physiology," tr. Baly, ii. 1392.

† Brierre de Boismont, op. cit. 468.

‡ Maury, "La Magie et l'Astrologie, &c.," 2me partie, chap. iii. passim.

quents as the sensation, without, however, being wholly and definitely confounded with it. In fact, there remains a character which is distinctive to the image: we soon recognise it as internal, we say to ourselves, at least after a moment, that the thing thus seen or felt is but a phantom; that our hearing, our sight, our taste, or our smell, have experienced no real sensation. We are not under the influence of hallucinations; we do not say—as sick people sometimes do*—"I saw and heard it as plainly as I now see and hear you. . . . . I assure you that what I saw was as clear as the day; and, if I doubt it, I must also doubt that I see and hear you."

To explain so important a difference, we must observe closely in what the recognition of an illusion consists. There are two moments during the presence of the image; one affirmative, the other negative; the second partially qualifying what the first began to affirm. In the case of a very precise and intense image, these two moments are very distinct: at the first it seems external, situated at such and such a distance from us, when a sound or visible object is in question; situated in our palate, nose, or limbs, when a sensation of smell, taste, local pain, or pleasure is in question. "The exercise both of conception and imagination,"† says Dugald Stewart, "is always accompanied with a belief (at all events, momentary) that their object exists. . . . . There are few persons who can look down from the battlement of a very high tower without fear, while their reason convinces them that they are in no more danger than when standing on the ground." In fact, when we look directly down to the ground, we imagine ourselves suddenly taken and thrown to the bottom; and this image alone is enough to make us shudder, since, for an imperceptible instant, it has the force of a belief; we draw back instinctively, as if we actually felt ourselves falling. We must admit, then, that "whenever the objects of

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* Baillarger, "Des Hallucinations," 374.

† "Philosophy of the Human Mind," chap. 3. i. 150–1. Ed. Hamilton.

imagination engross the attention wholly, they produce a temporary belief of their reality." This is why persons who experience very vivid images employ, to describe them, the same words as to denote the actual sensations; and, during some seconds, take their images for sensations. "I once heard," says Lieber, "a coloured preacher describing the torments of future punishment. He rose, not ineloquently, from the description of one anguish to another, when at last, carried away by uncontrollable excitement, he merely uttered, for more than a minute, a succession of inarticulate sounds or cries."* No doubt, during the minute in question, his mental vision had all the characters of physical vision. He had before him an imaginary hell resembling a real hell, and he believed in his internal phantoms as in real facts. "My imaginary persons," writes the clearest and most accurate of modern novelists, "*affect me,* pursue me, in fact, I live in them. When I was describing the poisoning of Emma Bovary I had so strong a *taste of arsenic in my mouth,* I was myself so far poisoned, that I had two consecutive fits of indigestion, and real indigestion, for I threw up my dinner."

An English painter,† whose rapidity of execution was marvellous, explained his mode of work in this way: "When a sitter came, I looked at him attentively for half an hour, sketching from time to time on the canvas. I wanted no more—I put away my canvas, and took another sitter. When I wished to resume my first portrait, *I took the man and sat him in the chair,* where I saw him as distinctly as if he had been before me in his own proper person—I may almost say more vividly. I looked from time to time at the imaginary figure, then worked with my pencil, then referred to the countenance, and so on, just as I should have done had the sitter been there—*when I looked at the chair I saw the man.* Gradually I began to lose the distinction between the imaginary figure and the real person;

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* "Smithsonian Contributions to Knowledge," vol. ii. p. 9.

† Wigan, "A New View of Insanity. The Duality of the Mind, &c.," p. 124.

and sometimes disputed with sitters that they had been with me the day before. At last I was sure of it; and then—all is confusion. . . . . I lost my senses, and was thirty years in an asylum." When he left the asylum he had still the power of painting a portrait from his internal image of the model, but was persuaded not to work, for fear of a return of the madness.

The chess-player I have mentioned, writes again: "I never think of distinguishing between my mental chess-board and the actual one. As far as I am concerned, they are one; and I could only establish a distinction between them by an effort of reasoning, the utility of which I have never experienced." Thus, while he is playing, his mental chess-board stands to him in place of the actual one.—In other cases, morbid or quasi-morbid, we see the image acquire complete and definite externality. "Recently," says M. Maury,* "my eyes were attracted by a dish of very scarlet cherries which were served at my table. Just after dinner, the weather grew stormy, and the air very close; I felt sleep coming over me, my eyes closed; I was then thinking of the cherries, and saw in a sleepy hallucination these same scarlet cherries lying on the same green porcelain dish on which they had appeared at dessert. Here was a direct transformation of my thought into sensation." Writers on insanity mention many instances of similar transformations.† "A young man who suffered from epilepsy, every fit of which was preceded by the apparition of an indented wheel, with a horrible figure in the middle, assured me that he had the power of producing hallucinations. He amused himself by conceiving some strange object to be present; and scarcely had he formed it in imagination before it appeared accurately before his eyes. I have myself seen an instance of this kind in a monomaniac,

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* "Le Sommeil, et les reves," 240.

† "Annales Médico-Psychologiques," 3me Série, ii. 389-90, M. Michéa—Cases collected by Abererombie, M. Moreau, Maisonneuve, &c.—See also, Baillarger "Des Hallucinations," "Mémoires de l'Académie de Médecine," tome xii. p. 250.

a man of cultivated mind and perfect sincerity of character, who assured me that he had but to recall to his mind or to imagine a person or thing, for the person or thing to appear at once before him with every appearance of externality."

There is no need to be ill or half asleep to watch the metamorphosis by which the image projects itself from within to an external position. "A friend of mine," says Abererombie,* "had been one day looking intensely at a small print of the Virgin and Child, and had sat bending over it for some time. On raising his head he was startled by perceiving at the farther end of the apartment a female figure of the size of life, with a child in her arms. The first feeling of surprise having subsided, he instantly traced the source of the illusion, and remarked that the figure corresponded exactly with that which he had contemplated in the print. The illusion continued distinct for about two minutes."† Goethe was able to produce in himself a complete illusion at will. "When I closed my eyes," he says, "*and depressed my head*, I could cause the image of a flower to appear in the middle of the field of vision; this flower did not for a moment retain its first form, but unfolded itself, and developed from its interior new flowers, formed of coloured or sometimes green leaves. These were not natural flowers, but of fantastic forms, although symmetrical as the rosettes of sculptors. I was unable to fix any one form, but the development of new flowers continued as

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* Op. cit. p. 63.

† Griesinger, "Traité des Malades Mentales" (translation by Doumic), p. 104. "Some observers are able to produce hallucinations at will; that is to say, ideas existing in their consciousness, and on which they firmly direct their attention, call into play the sensorial functions. A person who suffered from hallucinations of hearing observed that he could produce the voices himself, and said afterwards that this partly assisted him in recognising the error. M. Sandras speaks of hallucinations he himself suffered from during an illness in which he mistook his own thoughts and wishes for voices. These voices answered his mental questions as a person present would have done, but always in accordance with his wishes.

"We consider the phenomena of imagination as among the functions of the internal sensorial apparatus, and as differing from its other functions in intensity only."

long as I desired it, without any variation in the rapidity of the changes. The same thing occurred when I figured to myself a variegated disk. The coloured figures upon it underwent constant changes, which extended progressively, from the centre towards the periphery, exactly like the changes in the modern kaleidoscope."—Finally, hallucinations, that is to say, projections into the outer world of simple mental images, have been produced, not only in full health, but with the complete exercise, and, indeed, by the exercise of the will. "A German writer on insanity, Dr. Brosius, of Bendorf, mentions his having produced at will his own figure, which stood before him for some seconds, but which vanished immediately he attempted to fix his mind on his personal existence."*

These extreme cases show by their exaggeration the nature of the normal state. Just as by dissecting an hypertrophied stomach we succeed in distinguishing dispositions of the muscular fibres which are invisible in a healthy stomach, so by examining prolonged illusions, which last for seconds, minutes, or more, we discover the existence of fugitive illusions, accompanying ordinary images, but so rapid, short, and instantaneous, that we cannot isolate or observe them directly.—This illusion is none the less real, and the simple analysis of the words we use to denote the image bears witness to the double operation by which it is formed. We say that such an image, a phantom of hearing or sight, of taste or smell, which seems to be situated either in some part of our organs, or without us, seems, *erroneously*, to be situated there, since it is not there or without us, but *internal*. This phrase itself indicates the recognition and correction of an error, therefore of a preliminary error; we must have been deceived for the moment, since, a moment afterwards, we find out the mistake. The two operations,

* "Annales Médico-Psychologiques," ibid.—I have myself had, in a dream it is true, a vision of this kind (November, 1869). At the end of a dream, too long for narration, my own figure appeared seated in an arm-chair near a table, in a white dressing-gown striped with black; it turned towards me, and the shock was so great that I woke up with a start.

illusion and its rectification, follow so closely that they are confused into one. But suppress the rectification, the first operation, illusion, will alone remain, and its unaccustomed presence, when the couple is dissolved, will show us its fugitive presence in the couple when intact.

IV. This leads us to the consideration of cases in which the rectification cannot be effected. What usually effects it is the presence of a contradictory sensation. When the chess-player imagines a black and white chess-board two paces in front of him, and a moment afterwards his open eyes give him the sensation of a grey or dark wall at the same distance, and in the same direction, the sensation and image cannot co-exist. When the novelist imagines the crushing of moistened arsenic in his mouth, and "the horrible inky taste" which the poison leaves, if, a moment afterwards, he takes a mouthful of wine or a lump of sugar, the real and imaginary sensations exclude one another, and the momentary illusion caused by the image disappears under the ascendancy of the sensation. And thus it is that in most instances the passing error, connected for a moment with the presence of the image, disappears, if not at the same instant, without any appreciable interval elapsing, by the opposing shock of the real sensation.—Let us look, then, for a case in which the sensation disappears and becomes as it were absent; we find such a case in the reverie preceding sleep.* The sensations produced in us by the external world are then effaced by degrees; at last they seem suspended, and the images, no longer distinguished from sensations, become complete hallucinations. M. Maury succeeded, by having himself awakened at intervals, in observing a great number of them: for example, once, when suddenly roused up, "I saw my name very distinctly on a sheet of white paper, shining like the very smoothest English paper." He seated himself again in his easy-chair.

* Maury, "Annales Medico-Psychologiques," 3me Série, iii. 161.—And "Le Sommeil et les Rêves," chap. iv. M. Maury was the first to show, by a well-connected series of experiments, the near relationship of the sensation, the recollection, the image, and the hallucination.

"My head had scarcely sunk down before the hallucination returned; but now, instead of my name, I saw Greek letters and words which I spelt out mechanically, and almost with a movement of the lips. On several successive days I had, whether in bed or my chair, similar hallucinations or real dreams, in which I appeared to be reading Oriental characters. This reading of a word here and there was always accompanied by a feeling of fatigue in the eyes. . . . . Once, above all, I saw Sanscrit characters ranged in columns, according to the classification of grammarians, and these letters had a relief and a brilliancy which tired me. It must be observed that I had for some days been reading a number of grammars of Asiatic languages, and that the fatigue of my eyes was partly owing to this prolonged reading." Here we not only have the image which has become an hallucination,* but we see it in process of becoming such. We can watch the progressive diminution of the sensation which would contradict it, the suppression of the rectification which would pronounce it internal, and the increase of the illusion which causes us to take the phantasm for a real object.†

I know this state from my own experience, and have many times repeated the observation, above all in the daytime, when fatigued and seated in a chair; it is then sufficient for me to close one eye with a handkerchief; by degrees the sight of the other eye becomes vague, and it closes. By degrees, all external sensations are effaced, or cease, at all events, to be remarked; the internal images, on the other hand, feeble and rapid during the state of complete wakefulness, become intense, distinct, coloured, steady, and lasting; there is a sort of ecstasy, accompanied by a feeling of expansion and of comfort. Warned by frequent experience, I know that sleep is coming on, and that I must not dis-

* Brierre de Boismont, op. cit. 160. Mdlle. R., after a series of hallucinations, "characterized very clearly the state she had gone through. She could best compare it, she said, to an unpleasant dream."—Many sufferers from hallucinations have said the same, on their recovery.—The analogy between dreams and hallucinations is certain. See Maury, ibid. chap. vi.

† Mueller, Physiology, tr. Baly, ii. 1394.

turb the rising vision; I remain passive; and, in a few minutes it is complete. Architecture, landscapes, moving figures, pass slowly by, and sometimes remain, with incomparable clearness of form and fulness of being; sleep comes on, and I know no more of the real world I am in. Many times, like M. Maury, I have caused myself to be gently roused at different moments of this state, and have thus been able to mark its characters.—The intense image which seems an external object is but a more forcible continuation of the feeble image which an instant before I recognised as internal; some scrap of a forest, some house, some person which I vaguely imagined on closing my eyes, has in a minute become present to me with full bodily details, so as to change into a complete hallucination.* Then, waking up on a hand touching me, I feel the figure decay, lose colour, and evaporate; what had appeared a substance is reduced to a shadow. I have frequently thus watched in turn the filling out by which a simple image becomes an hallucination, and the obliteration which turns the hallucination into a simple image.—In this double transition, we are able to notice the differences, and perceive the conditions of the two states.

First, when we are going to sleep. As the image becomes more intense so it becomes more absorbing and independent. On the one hand, it attracts by degrees all the attention; external noises and contacts become less and less sensible; at last they are as if they did not exist. The image, on the other hand, becomes prominent and persistent; we seem no longer actors, but spectators; its transformations are spontaneous and *automatic*.† When attention and automatism are at their height, the hallucination is

* Maury, "Le Sommeil," 3me édition, pp. 448 and 453. Many instances are cited in support of this. "As soon as the mind rests on an idea, a corresponding hypnogogic hallucination is produced, if the eye be closed. . . . . The state of hallucination is nothing more than an intensity of the image-idea, owing to the internal parts of the sensorial apparatus having become more delicate and more readily excitable, and consequently undergoing, in the operation of conception, a more vigorous shock than in the healthy state—a shock, however, of the same nature as that which accompanies thought."

† An expression of M. Baillarger.

complete, and it is precisely by the loss of these two characters that it is destroyed.—Next, as to waking. On the one hand, at the light touch that arouses us, a part of our attention is brought back to the outer world. On the other hand, as memory returns, reviving images and ideas surround with their train the special image, they come into conflict with it, assume ascendancy over it, depose it from its solitary position, restore it to social life, and replace it in its habitual dependency. This opposition and contention cause the stupefaction of waking, and what we call being thoroughly awake is but the re-establishment of equilibrium.

The ordinary image then is not a simple, but a double fact. It is a spontaneous consecutive sensation, which, by conflicting with another sensation, primitive and not spontaneous, undergoes lessening, restriction, and correction. It comprises two momentary stages, a first in which it seems localized and external, and a second in which this externality and situation are lost. It is the result of a struggle; its tendency to appear external is opposed and overcome by the stronger and contradictory tendency of the sensation occasioned at the same moment by the action of the nerve. Under this effort it grows weak and thin, it is reduced to a shadow; we call it an image, phantasm, or appearance, and, however vivid or clear it may be, the conjunction of this negation is sufficient to deprive it of its substance; to dislodge it from its apparent position, and to distinguish it from the true sensation.

But to take the inverse case; it is allowed that not only in sleep but when awake, and for instance in a state of ecstasy or in the heat of action, though the nerve be excited, the sensation may be absent or as if absent, that is to say, not observed, annulled by the presence and preponderance of some other idea, image, or sensation. Such instances are by no means rare. At the bombardment of St. Jean d'Ulloa, the Mexicans fired a number of shot into a French vessel. A sailor called out "All right! No harm's done." The next minute he fell, fainting; a ball

had broken his arm; at the moment he did not feel it.*—So too in a calmer state, we may find sensations or fragments of sensations which are destroyed and no longer capable of contradicting the image. The image will then appear localized and external; and, though pronounced illusory by surrounding ideas, will continue to appear localized and external, since the sensation which could alone deprive it of this character is wanting, or is as if it did not exist. The hallucination is then complete, and what makes it so is the annulling the only sensation or fragment of sensation capable of reducing it.—When a man under an hallucination, with his eyes open, sees three feet from him the figure of a man where there is really a mere wall covered with a grey paper with green stripes, the figure covers a portion of this wall and renders it invisible to him; the sensations which this portion ought to excite are then non-existent; but nevertheless the retina, and probably the optic centres, are excited in the ordinary manner by the grey and green stripes. In other words, the preponderating image annuls the portion of sensation which would contradict it. If, as it often happens, the figure moves, the preponderating image, as it advances and covers each portion of the wall, is continually blotting out and exposing in turn distinct fragments of sensation. Reason is not wanting in such cases; for often when in this state the mind remains sound and the patient knows that the figure is not real; it is the *special reductive*, that is to say, the contradictory sensation, which fails in the conflict, and, instead of depriving the image of its externality, becomes itself effaced.

Accidents of this kind are frequent when one of the senses has been greatly fatigued. "It is well known that persons who are in the habit of using the microscope sometimes find objects which they have been examining for a long time re-appear spontaneously some hours after they have left their work."† M. Baillarger having worked some hours

* This fact was told me by an eye-witness.
† Baillarger, "Des Hallucinations," 460.

daily for several days, at preparing specimens of brains with fine gauze, "saw all at once gauze continually covering the objects in front of him. . . . . And this hallucination was repeated for several days." Here, it is evident the special reductive was wanting; in other words, the retina having before it a green carpet, or red chair, certain lines of green or of red, while producing on it their ordinary physical effect, excited only a sensation amounting to nothing. For this reason, a German physiologist, Gruithuisen,* who has observed his own hallucinations with great accuracy, affirms that he saw floating images *cover* the furniture of the room he was in.

Other cases show the partial re-establishment of the corrective sensation. A person, mentioned by Sir Walter Scott,† saw a skeleton at the foot of his bed. His doctor, wishing to convince him of his error, placed himself between the patient and the place assigned to the spectre. The patient then professed that he could not see the body of the skeleton, but that its skull was peering over the doctor's shoulder. This is why solitude, silence, obscurity, the want of attention, all circumstances, in short, which suppress or diminish the corrective sensation, facilitate or provoke the hallucination; and reciprocally, company, light, conversation, aroused attention, all circumstances giving rise to, or augmenting, the corrective sensation, destroy or weaken the hallucination.‡ "If we approach a patient suffering under hallucinations of hearing, and speak to him so as to fix his attention, we can convince him that his pretended invisible interlocutors are silent while the conversation lasts . . . . . ." A patient observed by M. Lélut, at the hospital of the Bicêtre, "ceased to have hallucinations when changed into another ward and with different neighbours. But this suspension lasted only a few days;

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* Baillarger, ibid. 333–334. † "Demonology and Witchcraft," p. 27.

‡ Baillarger, ibid. 440; and Brierre de Boismont, op. cit., 388. "Those nightly apparitions, which I called silly illusions by day, became frightful realities to me in the evening." p. 388.—"It constantly happened that the entrance of the servant freed her from the presence of the phantoms." p. 242.

the patient soon became accustomed to the new circumstances in which he found himself, and then fell again into false perceptions . . . . . With one patient there must be very keen impressions, uninterruptedly kept up, to suspend the hallucinations even for a short time. Scarcely is the sick man left to himself, scarcely have you ceased to excite him, when the phenomena recur. With others, on the contrary, the visit of the doctor to the ward is enough to cause a considerable suspension."—When M. Baillarger saw objects covered with gauze "it was principally in the dark, and when my attention was not engaged."* The same observer, having taken hasheich, could not get rid of his hallucinations while in the dark, and was compelled to light a candle.—Many patients who see in the dark various frightful figures, dying persons, corpses, &c., are freed from their visions as soon as a light is brought into the room. A lady with whom this is the case has been obliged for twenty years to have a light near her when asleep. An old servant, M. G., "as soon as she closes her eyes, sees animals, houses, meadows, &c. I have frequently myself pressed down her eyelids, and she described at once a crowd of objects which appeared to her." With some people, to enter a dark room is enough to produce hallucinations. "It is not then uncommon," says Mueller,† "to find distinct images of landscapes and similar objects floating before the eyes. I have been very subject to this phenomenon, but have got into the habit, whenever it occurs, of opening my eyes at once, and fixing them on the wall. The images still persist, but soon grow pale. They are seen whichever way the head is turned." Here the remedy is obvious; it consists in arousing a contradictory sensation. The phantom grows pale, and loses its externality in proportion as the sensation of colour excited by the wall becomes more clear and preponderant.—And the remedy is general; every shock that brings back the attention to real sensations; a cold bath, a

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* Ibid. 328, 329–330, 445–444.
† Op. cit., tr. Baly, ii. 1394.

douche, the arrival of an unexpected or important person, draws them from their indistinctness and nullity, re-establishes them more or less, and for a longer or shorter time, and consequently revives with them the particular sensation which is the special reductive of that illusion.

"In the summer of 1832,* a gentleman in Glasgow, of dissipated habits, was seized with cholera, from which he recovered. His recovery was unattended with anything particular, except the presence of phantasmata—consisting of human figures about three feet high, neatly dressed in pea-green jackets, and knee-breeches of the same colour. Being a person of a superior mind, and knowing the cause of the illusions, they gave him no alarm, although he was very often haunted by them. As he advanced in strength the phantoms appeared less frequently, and diminished in size, till at last they were not taller than his finger. One night, while seated alone, a multitude of these Lilliputian gentlemen made their appearance on his table, and favoured him with a dance; but being at the time otherwise engaged, and in no mood to enjoy such an amusement, he lost temper at the unwelcome intrusion of his pigmy visitors, and striking his fist violently on the table, he exclaimed, in a violent passion, 'Get about your business, you little impertinent rascals! What the devil are you doing here?' when the whole assembly instantly vanished, and he was never troubled with them more." The illness was drawing to a close, and his lively feeling of anger, together with the violent sensation of the blow on the table, suddenly restored their normal preponderance to the visual sensations which the portions of the table covered by the Lilliputians ought to have given him, but had ceased to give.

Other cases show with fuller detail how it is the corrective sensation leaves the sides, and appears on the scene. Nicolai,† the bookseller and academician of Berlin, having

* Macnish, "Philosophy of Sleep," p. 290.

† Brierre de Boismont, op. cit. 33, citing from *Berliner Monats-schrift*. 1799. Mai.

suffered from considerable vexations, and a periodical blood-letting to which he was accustomed having been omitted, tells his story thus:—"On the 24th of February, 1791, having had a violent altercation, I saw on a sudden, about ten paces from me, the figure of a corpse. . . . . The apparition lasted eight minutes. At four in the afternoon, the same figure re-appeared. . . . . At six, I distinguished several figures having no connexion with the first. . . . On the following day, the figure of the corpse disappeared; it was replaced by other figures, sometimes representing friends, but more frequently strangers. . . . . These visions were as clear and distinct in solitude as in company, by day as by night, in the streets as in my own house; *only they were less frequent when in strange houses.*" They represented men and women walking as if on business, then persons on horseback, dogs, and birds. There was nothing particular in their looks, stature, or dress, "*but they were a little paler than in real life.*"* At the end of four weeks, their number increased; they began to talk to one another, and sometimes to address him, usually in pleasing language. He distinguished clearly these involuntary hallucinations from voluntary images. When certain figures he was acquainted with had thus passed before him, he determined to attempt to reproduce them mentally. "But," says he, "while seeing distinctly in my mind two or three of them, I could not succeed in making the internal image external. . . . . On the other hand, some time after, I perceived them afresh when I was not thinking of them."—The special reductive was wanting in the hallucination; on the other hand, it was at work in the case of ordinary attention, and simply because the degree of attention was ordinary. In the first

* M. Brierre de Boismont (op. cit. 240) gives an account of a person who, during an attack of pneumonia, had hallucinations of this kind, while preserving, like Nicolai, all his reason.

"Sometimes these figures presented themselves suddenly, but more frequently did not become distinguishable till after an interval, as though they had passed through a mist before showing themselves distinctly. Each figure remained visible five or six seconds, then disappeared, getting feebler by degrees till nothing remained but an opaque dull cloud, from the midst of which another figure immediately appeared."

ease, the image arising of its own accord, spontaneously, without visible connexions or antecedents, and with personal automatic power, destroyed the special reductive. In the second ease, the image arising by an effort of the balanced group of ideas and desires which we term ourselves, allowed the special reductive to do its work.—After about two months, leeches were applied to the patient to make up for the omitted bleeding, and he found his normal sensations reappear, not all at once, but by portions and degrees. "During the operation," says he, "my room was filled with human figures of all kinds. This hallucination lasted uninterruptedly from eleven in the morning to half-past four, just when my digestion was commencing. I then perceived the movements of the phantoms getting *slower*. Soon afterwards they began *to grow pale:* at seven they had *a whitish look*, they moved *very slowly*, though their outlines were as distinct as before. By degrees they became *misty*, and appeared *to dissolve into air*, whilst *certain portions of them remained still visible* during a considerable time. At about eight o'clock, the room was quite clear of these fantastic visitors."

When we are suddenly roused from sleep in the midst of a vivid dream, we experience an impression like this, though of far shorter duration. In such a case, I have often seen, for a passing moment, the image *grow pale*, waste away, and evaporate; sometimes, on opening the eyes, a fragment of landscape or the skirt of a dress appears still to float over the fire-irons or on the black hearth.—So, while Nicolai was recovering, the parts of the wall or furniture covered by the phantoms succeeded by degrees in producing their normal effect. The sensation which they would naturally excite by their action on the nerve, and through that on the brain, is no longer paralysed. At first, this sensation recovers a portion of its strength, and contends on equal terms with the image; for the phantom, if still present, is misty, and the furniture or wall is vaguely apparent behind it. Soon, a fragment of the sensation regains all its preponderance; a leg or the head of a phantom disappears owing to the reappearance of the portion of furniture which it hid. Then,

the whole sensation finds itself restored and complete, the phantoms have vanished, and all that remains of them is the internal image which enables us to describe them.

Here we see very clearly the connexion of the image and sensation; it is an *antagonism*, such as is met with between two groups of muscles in the human frame. In order that the image may produce its normal effect, that is to say, may be recognised as internal, it must undergo the counterpoise of a sensation; and if this counterpoise is absent, it will appear external. Similarly, in order that the muscles on the left of the face or tongue may produce their normal effect, the corresponding muscles on the right must be intact. In the absence of this counterpoise, the face or tongue are drawn towards the left. The paralysis of the muscles of one side produces a deformation of the other, as the weakening or extinction of the reductives of an image produces an hallucination.

As a general rule; normal sensations of any one sense, and usually those of the different senses, hold together. We have seen many proofs of this in the cases cited. When the attention is attracted by a normal sensation, that is to say, when this sensation regains its ordinary preponderance, the chances are that the other annulled sensations regain their ascendancy at the same time. The patient who is freed at once from his illusions by the light of a candle, the unfortunate man who hears voices which cease when conversation becomes interesting, the lunatic who regains his senses after a sudden dash of cold water, are cured for a longer or shorter time by the more or less durable energy restored to the special reductive. So, in facial paralysis, the face drawn on one side by the action of the left muscle, regains its ordinary form as the muscles on the right gradually regain their power under the action of electricity.

In other cases the cure follows from the same principles, but is obtained by an inverse process; I mean those in which the patient is haunted, not by hallucinations, that is to say, by images capable of annulling the normal sensation which ought to counteract them, but by illusions, that is to say, by images excited by the normal sensation, and so

strong, precise, and absorbing that no actual sensation from without could have greater power. A state of excitement and expectation in the subject will often cause a sensation, which would be accompanied in a calm state by images of moderate activity, to communicate an extraordinary clearness and force to the image. "A whole ship's crew were thrown into consternation by the ghost of the cook, who had died a few days before. He was distinctly seen by them all, walking on the water with a peculiar gait by which he was distinguished, one of his legs being shorter than the other. The cook, so plainly recognised, was only a piece of old wreck."* The superstitious sailors who had the figure of their shipmate and his gait fresh in their minds, all, without previous concert, underwent the same illusion at the sight of the uneven motion of the wreck, and their imagination found in the sensation a ground to build on.

What was here effected by credulity may be caused by disease. We see insane persons who lick the surface of a wall and imagine themselves to taste delicious oranges, or who, when given ripe fruit, find it rotten or poisoned; who, when they see one person, insist on taking him for another; who see the furniture of their room move about, grow bigger, or take fantastic and frightful forms.† In such cases it often happens that by suppressing the normal sensation, which is the starting point of the illusion, we suppress the illusion itself, and the special reductive is found, not in the predominance, but in the absence of that sensation.‡ "D. ——, seventy-five years old, of sound mind, came home one day, frightened by a thousand phantoms which were following him. Whichever way he looked, *objects were transformed into spectres,* representing sometimes huge spiders which ran at him to drink his blood; some-

* Moore, "The Power of the Soul over the Body," p. 170.

† Brierre de Boismont, op. cit. 777. This was the case with Don Quixote; the sensation of two great whirlwinds of dust excited in him the image, and consequently the sensation, of two armies.

‡ See Griesinger, op. cit. 103, for different instances.

times soldiers with pikes. He was bled in the foot; the visions continued, accompanied by obstinate attacks of sleeplessness; a bandage was applied to his eyes; then they ceased, but returned as soon as the bandage was taken off, until the patient kept it on uninterruptedly for a night and part of a day. From that time he only saw phantoms at long intervals, and after some days they disappeared entirely. The patient has had no relapse." Here, in place of strengthening the special reductive, the special excitant was suppressed, and the same result arrived at by different means.

In a very curious observation made by Dr. Lazarus on himself, we see no less clearly how the exciting sensation, alternately present and absent, alternately excites and suppresses the illusion. "I was on the Kaltbad terrace at Rigi, on a very clear afternoon, and attempting to make out the Waldbruder, a rock which stands out from the midst of the gigantic wall of mountains surrounding it, on whose summits we see like a crown the glaciers of Titlis, Uri-Rothstock, &c. I was looking alternately with the naked eye and with a spy-glass; but could not distinguish it with the naked eye. For the space of six to ten minutes I had gazed steadfastly upon the mountains, whose colour varied according to their several altitudes or declivities between violet, brown, and dark green, and I had fatigued myself to no purpose, when I ceased looking and turned away. At that moment I saw before me (I cannot recollect whether my eyes were shut or open) the figure of an absent friend, like a corpse.—I ought here to mention that I have been for years in the habit of noting down in writing every group of representations which has arisen, whether dreaming or awake, with special force, precision, and clearness, and has affected me vividly enough to induce the thought of the representation as a presentiment. I ought further to mention that I have never had the fortune to see one of such presentiments verified, though they have often been as sudden, clear, and apparently inexplicable, as one could wish. In addition to this, I have acquired the habit,

intelligible enough in a psychologist, of tracing backwards from such incidents, and following up the whole series of antecedent representations. I have very often succeeded in explaining, by the known laws of association of ideas, how such presentiments have contrived to find place in the series of my thoughts at the time.

"On this present occasion, I asked myself at once how I had come to think of my absent friend?—In a few seconds I regained the thread of my thoughts, which my looking for the Waldbruder had interrupted, and readily found that the idea of my friend had by a very simple necessity introduced itself among them. My recollecting him was thus naturally accounted for.—But in addition to this, he had appeared as a corpse. How was this?—At this moment, whether through fatigue or in order to think, I closed my eyes, and found at once the whole field of sight, over a considerable extent, covered with the same corpse-like hue, a greenish-yellow grey. I thought at once that I had here the principle of the desired explanation, and attempted to recall to memory the forms of other persons. And, in fact, these forms too appeared like corpses; standing or sitting, as I wished, all had a corpse-like tint. The persons whom I wished to see did not all appear to me as sensible phantoms; and again, when my eyes were open, I did not see phantoms, or at all events only saw them faintly, of no determined colour. —I then inquired how it was that phantoms of persons were affected by and coloured like the visual field surrounding them, how their outlines were traced, and if their faces and clothes were of the same colour. But it was then too late, or perhaps the influence of reflection and examination had been too powerful. All grew suddenly pale, and the subjective phenomenon, which might have lasted some minutes longer, had disappeared.—It is plain that here an inward reminiscence, arising in accordance with the laws of association, had combined with a *consecutive sensation of sight*. The excessive excitation of the periphery of the optic nerve, I mean the long-continued preceding sensation of my eyes when contemplating the colour of the mountain, had

indirectly provoked a subjective and durable sensation, that of the complementary colour; and my reminiscence incorporating itself with this subjective sensation, became the corpse-like phantom I have described."* This singular case shows us the abnormal effect of sensation. When it exists, it increases the force and clearness of an ordinary vague representation till it turns it into a sensible phantom. When it ceases, the force and clearness of the sensible phantom are decreased, till it returns to its ordinary state, that is, one of vague representation.

Thus, in every process by which the exaggeration of images is combated, all we attempt is to set up an equilibrium, not that of a balance of which the two scales are on a level, but that of a balance in which one scale is lower than the other. In the normal state of wakefulness, the first scale which holds the sensations proper, is the heavier; the second and lighter scale holds images proper. The two scales in the normal state are, for the moment, on a level; but the heavier scale immediately weighs down the other, and our images are recognised as internal. Sometimes, in illness, a weight passes from the first to the second; the second then weighs down the first, and we have an hallucination proper; we are then obliged to add new weights, that is, new sensations, to the first, to destroy the preponderance. Sometimes, again, a thread attaches a weight of the second scale to a weight of the first, the first scale can no longer descend, and we have an illusion proper; the first means are no longer applicable; it would be idle to add new weights, we must remove from the first scale the weight with the thread which keeps the scales on a level, in spite of the inequality of their loads. In the first case, the normal state is re-established by adding; in the second, by taking off, weights.

V. But these are not the only means in question; for, in addition to the weights constituted by the sensations, there are others, lighter, but still usually sufficient in the

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* "Zur Lehre von den Sinnestauschungen," Berlin, 1867.

healthy state to deprive the image of its externality; I mean recollections. These recollections are themselves images, but connected together and undergoing a recoil which gives them a situation in time, by a mechanism we shall inquire into hereafter. General judgments acquired by experience are associated with them, and form with them a group of elements connected among themselves, and so balanced, by their relations to one another, as to form a whole of considerable cohesion, and lending its entire force to each of its elements.—Every one may observe in his own case the reductive power of this group. A few days ago, I had a very clear and perfectly connected dream, in which I committed a ridiculous and enormous absurdity, too much so to describe; let us take something less glaring, such as quietly drawing off one's boots in company, and placing them on the mantelpiece beside the clock. It happened in a drawing-room I like very much; I saw distinctly the principal guests, their dress, their attitudes, I spoke to them, the scene was long, and the impression so clear that a quarter of an hour after I could have described it with every detail. I felt ill at ease, and was wondering howI could get out of my difficulty.—Just then I began to awake, and this state lasted two or three minutes. My eyes were still closed; but probably, through some feeling of cold or actual movement, ordinary consciousness was reviving, though feebly. In the first place, I was astonished at having shown such frightful ill-breeding; in other words, the vague recollection of my previous actions rose up, and came into opposition with my dream; this recollection became more precise, and brought on others; the lines of the past were reformed, and at the same time and in the same degree, the absurdity I had dreamed of, finding no standing-room, disappeared and evaporated. Then came this judgment, based on general ideas:—"It is a dream." The ridiculous image, at once and definitively, became distinct and severed from the real recollections, and entered the region of pure phantasm. I had not yet opened my eyes; the sensation of present objects had not performed its work;

at all events, it had only done so to the extent of reviving ordinary recollections and general judgments; these judgments and recollections, by the fixedness of their order and the cohesion of their group, had effected the necessary reduction, and overcome the natural tendency by which the image causes illusion.

In some cases this repression is much slower. M. Baillarger dreamed one night that a certain person had been appointed editor of a newspaper; in the morning, he believed it to be true, and mentioned it to several persons, who were interested to hear it;—the effect of the dream persisted all the forenoon, as strongly as that of a real sensation; at last, about three o'clock, as he was stepping into his carriage, the illusion passed off; he comprehended that he had been dreaming; so here the reductive group did not regain its ascendancy for half a day.—In this respect, the detail and intensity of a voluntary image have sometimes the same power as a dream. We find many examples of this in the lives of Balzac, Gérard de Nerval, Edgar Poe, and other great artists. Balzac once, at the house of Mme. Delphine Gay, was describing with animation a fine white horse he intended to present to Sandeau; some days after he imagined he had actually given it, and inquired of Sandeau about it; probably, his friend's astonishment and denial disabused him of the notion of his present.

On other occasions, the reductive group is weakened, and is not sufficient to check even an ordinary image. "An old man," says M. Maury, "who had travelled a great deal, had also read many accounts of travels over ground where he had not been. The recollections of his wanderings and of his readings had ended by becoming completely confused together; and all seemed to occur at once to his mind as he lay on his sofa, and he would gravely relate things he had read. For example, he would say that he had been in India with Tavernier, in the Sandwich Isles with Cook, and had then returned to Philadelphia, and had served there under Lafayette. This last statement was true."

The notions of chronology and order of time were effaced, and no longer performed their ordinary office.

Persons with lively imaginations are constantly forced to make reductions which this old man had ceased to make; the general order of their recollections, fortified by the addition of some new observation, is generally sufficient for this. But when an image has aequired extraordinary intensity, and annuls the particular sensation which is its special reductive, though the order of recollections may exist and conclusions be come to, we have, nevertheless, an hallucination; in fact, we may know that we are under an hallucination, but still the image appears external; our other sensations and images still form a balanced group, but this reductive not being the special one, is insufficient.—"Dr. Gregory had gone to the north country by sea, to visit a lady, a near relation, in whom he felt deeply interested, and who was in an advanced state of consumption. In returning from the visit, he had taken a moderate dose of laudanum, with the view of preventing sea-sickness, and was lying on a couch in the cabin, when the figure of the lady appeared before him in so distinct a manner that her actual presence could not have been more vivid. He was quite awake, and fully sensible that it was a phantasm produced by the opiate, along with his intense mental feeling, but he was unable by any effort to banish the vision."* In fact, the sensation which ought to have been produced in him by the grey wall of the cabin was annulled as regarded the whole surface which the phantom seemed to cover; and it is very clear that reasoning has not the force of a sensation.—Many circumstances, organic or moral, the action of haschich,† of datura, of opium, the coming on of apoplexy, different inflammatory diseases, different cerebral alterations, in short, a number of causes, more or less remote or near, are capable of thus strengthening an image or

* Abercrombie, "Inquiry concerning the Intellectual Powers," p. 359.

† Brierre de Boismont, ibid. 200. Accounts given by several persons who had taken haschich. Ibid. 374.

series of images so as to annul the special sensation which should repress it, and thus bring on hallucination.—But if in all these cases the illusion, circumscribed by secondary reductives, is at last destroyed by the special one, we meet with a still greater number in which this is not the case. Very frequently, patients, having admitted for a length of time that their phantoms were only phantoms, have ended by believing them to be real, and equally real with the persons and objects surrounding them, and this too with so absolute a conviction that no experience of their own or evidence of others can cure them of their error. In such cases the second class of reductives are annulled, as well as the special one; the preponderating image, having paralysed the contradictory sensation, extends its dominion over the contradictory group of other normal images, and excites delirious ideas and unreasonable impulses. The person under hallucination becomes a madman; the loss of local equilibrium has gradually brought on an increasing loss of general equilibrium, as the paralysis of the muscles on the right, after causing a deformation and shrinking of the face towards the left, may affect by sympathy the adjoining functions, and produce general disease throughout the body.

Examples of this are numerous; I have chosen one, reported by Dr. Lhomme, which shows in detail the several stages of this spontaneous transformation, and throws great light on the mechanism of the mind.

In March, 1862, the gendarme S. was on duty at an execution. He was on guard with the prisoner during part of the night, assisted at the *toilette,* and was a few feet from the scaffold when the execution took place. When the head fell, he saw the executioner take it up *to put it in the basket.* . . . . He says that this made a deep impression on him; he had been seized with a nervous trembling which he could not control, at the moment he saw the prisoner brought up with his outer clothes removed and neck bare; and long after the execution, *the figure of the bleeding head which he had seen thrown into the basket* was constantly before him.

Some time after, talking with the quartermaster, he said

that he had no great opinion of Protestants. "He told me I was wrong; that there were many very good people among them, and even some persons of high rank, and mentioned, as an instance, the Minister of War. I kept thinking of this conversation, *and it came into my head that the quartermaster would probably report me to the Minister of War. Some days afterwards I dreamed that I was actually condemned to death* by the Minister's order, without having had a trial. I thought in my dream that *I was bound with straps and was being rolled like a barrel towards the guillotine. This dream impressed me vividly.* I told it to a comrade, who laughed at me, *but it often recurred to my mind!*"

On the 1st of August, going from Saneerre to Sancergues, he got drunk, arrived too late, and found the barracks closed. Next day the quartermaster told him that he should report him to the lieutenant for being late.—The 2nd of August he was "out of spirits, but not ill." The 3rd of August, he says, "I did not feel all right, though I had slept well; *I kept thinking of my dream.* . . . . When I went on duty as sentry, I thought every one was staring at me, and that I heard my comrades and other persons *whispering* that I was going to be *guillotined.*"

That evening he went to bed at eleven, having cleaned his accoutrements for next day's drill. "I had perhaps been in bed twenty minutes, and had not fallen asleep, when I heard *a noise* in the clock over the mantelpiece, and then *a voice* came from it, and said to me, "*You must die, you must die. Your head will be cut off in two days. We must have your head, we must have your head!*" He started up and looked in the clock, but there was nothing to be seen, so thinking it a joke of his comrades, he went to bed again. The voice began again, and he was looking about during part of the night. About four in the morning he rose, without having slept, and went to drill, but said nothing of the voice he had heard, as he "still thought that his comrades had been playing him a trick." Coming back he was tired, but could not eat, and cleaned his accoutrements; he

felt no inclination to sleep, and did not go to bed till one in the morning. He was scarcely in bed when he heard the same voice and same words proceeding from the clock. "Then I rose and walked up and down, *very certain* that they would execute me next morning, and that that was why the lieutenant had remained at Sancergues."

He rose early. "The quartermaster was surprised to see me ready so soon, and said something in a low tone to my comrades. *I thought I heard,* 'See that your carbines are loaded; watch him that he does not escape!'"

On this he found his horse, and set off at a gallop without knowing where he was going. At last he came to a wood, got off, and hid himself in a thicket, and loaded his carbine to defend himself; then he determined to kill himself, and took off his boots that he might draw the trigger with his foot, but first knelt to say a prayer. "I was soon interrupted by a figure with a huge beard, who disappeared as soon as I took aim at him; and three times running I was stopped by the same apparition or by figures of Punch, which disappeared as I was going to fire. I saw also girls with hooped petticoats, dancing in the trees above my head."

The other gendarmes came up; he threatened to fire on them, attempted to take off his white breeches to hide himself better; then, hearing them return, he fired on the foremost of them, and attempted to escape, but was taken. "I was quite convinced that they were going to take me to execution, and called out 'Murder!' I even thought more than once that I saw a gendarme draw his knife from his pocket to stab me, and my cries increased." He was bound, and a guard put over him, and did not sleep all night. "I continually heard female voices saying, '*Poor fellow! how unfortunate! He must be guillotined in two hours, and his head sent to Paris by six o'clock. The quartermaster has the basket for it.*' The whole day and night of the 6th I had the same ideas, and could not sleep for a moment or take any kind of nourishment. It was not till the 7th that I was able, during the daytime, to throw myself on my bed and sleep for a short time. When I woke I found my

head completely clear, though I recollected perfectly all that had taken place. I expressed my sorrow to my comrades for what had passed, and asked at once after the one I had wounded." From that time the hallucinations ceased; the patient's reason is unaffected; he was calm and quiet during his stay in an asylum, and is replaced in the brigade of Gendarmerie, and has regularly performed his duty since.

Few examples are more instructive than this; we follow the hallucination from its first rise to its completed state and its cure. The mental abscess begins with a terrible image, combined with extreme emotion.—The image constantly reviving besets the mind.—It attaches itself to the idea of self, and S—— imagines a case in which he may well be in personal danger.—This connexion becomes defined, and in a dream he sees himself led to the guillotine. The dream returns to his mind during the day. After he has committed a fault it recurs with greater force.—The mental words by which he expresses it to himself become a whispering of his comrades, and then a voice in the cloak.—The voice returns, and his conviction grows firmer.—Unconnected hallucinations of sight, then of the touch, follow.—For thirty hours the voices continue, and the hallucination of the ear is at its height.—Then he becomes suddenly freed from them, as if the mental abscess having ripened, had broken of itself.*

VI. From these examples we can form a notion of our intellectual machinery. We must lay aside the words reason, intelligence, will, personal power, and even self, as we lay aside the words vital force, medicative virtue, vegetative soul; they are literary metaphors, capable at the most of convenient use by way of summary or abbreviation, to express general states and combined effects. All that observation detects physiologically in the living being are cells of different kinds, capable of spontaneous development, and modified in the direction of this development by the concurrence or antagonism of their neighbours. All

* "Annales Médico-Psychologiques," 4e Série, ii. 238.

that observation detects psychologically in the thinking being are, in addition to sensations, images of different kinds, primitive or consecutive, endued with certain tendencies, and modified in their development by the concurrence or antagonism of other simultaneous or contiguous images. Just as the living body is a polypus of mutually dependent cells, so the active mind is a polypus of mutually dependent sensations and images, and in the one case as in the other, unity is nothing more than a harmony and an effect. Every image is possessed of an automatic force, and tends spontaneously to a particular state; to hallucination, false recollection, and the other illusions of madness. But it is arrested in its progress by the contradiction of a sensation, of another image, or group of images. The mutual arrest, the reciprocal clash, the repression, produce by their combined effect an equilibrium; and the effect we have just seen produced by the special corrective sensation, by the connexion of our recollections, by the order of our general judgments, is but an instance of the constant re-arrangement and incessant limitation which innumerable incompatibilities and conflicts are incessantly bringing about among our images and ideas. This equilibrium is the state of reasonable wakefulness. As soon as it is at an end by the hypertrophy or atrophy of an element, we are mad, wholly or partially. When it lasts over a certain time, the fatigue is too great, and we sleep; our images are no longer reduced and guided by antagonistic sensations coming from the outer world, by the repressive effect of combined recollections, by the dominion of well-connected judgments; so they then acquire their full development, turn into hallucinations, arrange themselves spontaneously according to new tendencies, and sleep, though crowded with intense dreams, is a rest, since, suppressing a constraint, it brings on a state of relaxation.

But in the meanwhile the reader has been able to ascertain the nature of the image. For this we must remain at the point at which we have provisionally placed ourselves. We do not yet enter upon physiology, but confine ourselves

to pure psychology. We do not talk of nerves, spinal marrow, or brain. We leave aside the unknown excitation which the external extremity of the nerve undergoes by contact with an external object, and which transmits itself to the spinal marrow, passes thence to the surface of the brain, spreads among its circumvolutions, becomes persistent in the nervous centres, and is, later on, renewed there. We do not examine the link connecting the sensation with the image. We observe man, not with the scalpel and microscope, but with that internal view we call consciousness, and we compare directly the image and the sensation.—In this limited field, and in this precise sense, we have just seen that the image, with different physical stimulants, and a special reductive, is of the same nature as the sensation. It is the sensation itself, but consecutive or reviving; and from whatever point we consider it, we find it coincide with the sensation.—It furnishes the same combinations of derived and superior ideas; the chess-player who plays blindfolded, the painter who copies an absent model, the musician who hears a score when he looks over the sheet of music, form the same judgments, go through the same reasonings, and experience the same emotions, as if the chess-board, the model, the symphony, were actually experienced by their senses.—It provokes the same instinctive movements and the same associated sensations: the man who has a disgusting medicine put before him, who is about to undergo a surgical operation, who recalls a melancholy or terrible accident, shudders, sweats, or is sick, in presence of the image alone, as he would if the sensation were itself present.—Though generally fragmentary, fugitive, and weak, it arrives in many cases, in the extreme concentration of excessive attention, in violent and sudden emotions, at a state bordering closely on the corresponding sensation, and attains the fulness of detail, the clearness, energy, and persistence of the sensation.—Finally, taken alone and freed from the reduction of its special corrective, it acquires apparent externality, the want of which, even at its maximum of intensity, usually

distinguishes it from the sensation; it acquires this for an imperceptible moment in the majority of cases; for some seconds or minutes in certain well-authenticated instances; for several hours, days, or weeks in the states of half sleep, complete sleep, ecstasy, hypnotism, somnambulism, hallucination; in the disorders produced by opium or haschich, in various cerebral or mental maladies; and acquires it with or without lesion, or with either partial or total lesion, of the normal equilibrium which subsists between other ideas and images.—We may define it, then, as a repetition or revival of the sensation, while at the same time we distinguish it from the sensation; first, by its origin, since it has the sensation as its antecedent, while the sensation is preceded by an excitation of the nerve; and again, by its association with an antagonist, since it has several reductives, among others, the special corrective sensation, while the sensation itself has no reductive.

Arrived at this we understand its nature: in reviving the sensation, it replaces it; it is its *substitute;* that is to say, a thing differing from it in certain respects, like it in others, but so that both differences and resemblances have their advantages. What these advantages are we shall see later on. Images of a certain kind constitute recollections; that is to say, knowledge of past events. Images associated with the sensations of the different senses, especially with those of sight and touch, constitute acquired perceptions; that is to say, all such parts of our knowledge of external individual objects as extend beyond actual crude sensation. Images of a certain kind, and associated in a certain way, constitute previsions; that is to say, knowledge of future events.—Just as the knowledge of general qualities is only possible by the *substitution* of signs for perceptions and images, so knowledge, whether of events past or to come, or of the grouped properties which make up every individual external object, is only possible by the *substitution* of images for sensations.—Nature employs, in the two cases, the same process to arrive at the same effect; psychology here repeats

physiology. As we see in the history of respiration or of locomotion a physiological element become, by a slight modification, the instrument of a more complicated function, then, by a second additional modification, execute a still superior function; so in the history of intelligence, we see a psychological element give rise, by a small modification, to very extended operations, then, by a second added modification, accomplish operations so complex, so delicate, and so numerous, that they seem destined to remain for ever beyond our grasp.

CHAPTER II.

LAWS OF THE REVIVAL AND OBLITERATION OF IMAGES.

I. WHEN we see or touch an object, when we hear a sound, when we experience a sensation of taste, of smell, of cold, of pain, in short, any sensation whatever, we usually retain the image during a second or two, unless some other sensation, image or idea, comes in the way, and suppresses instantly this prolongation and echo. But in many cases, and above all when the sensation has been a prominent and important one, the image revives of itself after a longer or shorter period of suppression. This spontaneous revival is its fundamental property, and may be effected after long periods have elapsed. Many of us have recollections which go back twenty, thirty, forty years, or more. I know a person, born in a little provincial town, who can relate with the utmost exactitude all the circumstances of a visit of the Empress Marie-Louise in 1811, can describe her dress, the dresses of the ladies and young girls appointed to receive her, can hear mentally the sound of her voice, see her gestures, her face, the attitudes of the persons appointed to present her with an address, and many other things.—What renders these revivals still more remarkable is that they frequently occur without the image having reappeared during the whole interval. On returning, after many years' absence, to one's father's house, or to one's native village, numbers of forgotten objects and facts unexpectedly re-appear. The mind, suddenly thronged by their stirring crowd, resembles a box of dried rotifera, which have lain inert some ten years, but when sprinkled with water, at once revive and twist about. We mount the dark staircase, we know where to find the handle

of the door, we imagine ourselves seated at table in our accustomed place, we see the water-bottle on the right, and the salt-cellar on the left, we seem to taste the flavour of some Sunday dish. We look up at the wall and are surprised not to find there some old engraving we had stared at as children. We see the gesture and stoop of some former guest, the square body and long folds of a blue dress; we almost hear the tones of voices which have long been still. We come to the well, and recall the vague terror with which as children, mounting on tiptoe, we looked on the obscure depth and the trembling reflection of the cold water at what seemed to us an infinite distance below.

Some people unconsciously preserve certain reviving shreds of long-distant impressions.—"There often recurred to my mind," says M. Maury, "without my knowing why, three proper names, each accompanied by the name of a town in France. One day I came across an old newspaper and commenced to read it for want of anything better to do. Among the advertisements I saw one of a depôt of mineral waters, with the names of the druggists who sold them in the principal towns of France. There I found my three unknown names with those of the three towns with which they were connected in my mind. All was explained; my memory, which is excellent for words, had preserved a recollection of these associated names, on which my eyes must have rested while I was looking (as had happened about two months previously) for the address of a depôt of mineral waters. But the circumstance had gone out of my mind without the recollection being wholly effaced. Now, certainly, I could not have paid much attention in so rapid a glance."

Illness sometimes causes a revival of such images as this of names, which seemed, not merely torpid, but hopelessly extinct. "A girl was seized with a dangerous fever, and, in the delirious paroxysm accompanying it, was observed to speak in a strange language which, for some time, no one could understand. At last it was ascertained to be Welsh —a tongue of which she was wholly ignorant at the time she

was taken ill, and of which she could not speak a single syllable after her recovery. For some time the circumstance was unaccountable, till, on inquiry, it was found that she was a native of Wales, and had been familiar with the language of that country in her childhood, but had wholly forgotten it afterwards."*—Again; some fugitive impressions, not observed at the time, may rise anew with strange power and automatic exactness. Many medical writers have noticed the story† of a young woman of five-and-twenty who could neither read nor write, who, during an illness, repeated long passages of Latin, Greek, and Rabbinical Hebrew, but on recovery, spoke nothing but her own language. During her delirium, several of these fragments were taken down in writing from her own mouth. After inquiry, it was found that she had lived, when nine years old, with her uncle, a clergyman of considerable learning, who was in the habit of walking of an afternoon in a passage adjoining the kitchen, and there reciting favourite passages of Rabbinical Hebrew and Greek. On referring to his books, there were found, word for word, many of the passages repeated by the sick girl. The noise and articulation of his voice had remained fixed in her ears. She had heard them as she repeated them without understanding them.‡ Hasehich, the death-agony,§ great and sudden

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* Macnish, "Philosophy of Sleep," p. 55, n.; and see two analogous facts cited by Azam, "Annales Médico-Psychologiques," 3e Série, vi. 443.

† Coleridge, "Biographia Literaria." vol. i. p. 117.

‡ "A man of ordinary ability, servant of a Spanish ambassador, had frequently to be present during important conferences, but did not appear to have recollected anything of what had passed. He was seized with brain fever, and in his delirium repeated with considerable order many discussions he had heard on the political interests of different powers, so much so that the ambassador, who had considered him only as a faithful servant, came to hear him, and thought of promoting him to be his secretary; but the affection of the brain passed off, and when the patient recovered, this memory had departed."—(Grimaud de Caux, cited by Duval Jouve, "Traité de Logique," 159.)

§ "I was once told by a near relative of mine, that having in her childhood fallen into a river, and being on the very verge of death, ... she saw in a moment her whole life, arrayed before her as in a mirror, not successively, but simultaneously; and she had a faculty developed as suddenly for comprehending the whole and every part."—De Quincey, "Confessions, &c." p. 258.—De Quincey and other opium-eaters have observed in themselves this faculty of living mentally, during a dream of a few minutes, a life of many years, and even of many centuries.

emotion, sometimes cause revivals, equally minute, of sensations as little observed and still farther distant.—We can assign, then, no limits to these revivals, and are compelled to ascribe to every sensation, however rapid, unimportant or obliterated it may have been, an indefinite power of revival, without mutilation or loss, even after an enormous distance of time; just as a vibration of ether, which, starting from the sun, transmits itself through millions of leagues till it reaches our optical apparatus, with its special spectrum and its proper rays, the same at its starting-point and at its place of arrival, intact, and capable, by its exact conservation, of manifesting on the instrument receiving it the nature of the fire from which it is emitted.

II. If, however, we compare different sensations, images, or ideas, we find that their aptitudes for revival are not equal. A large number of them are obliterated, and never reappear through life; for instance, I drove through Paris a day or two ago, and though I saw plainly some sixty or eighty new faces, I cannot now recall any one of them; some extraordinary circumstance, a fit of delirium, or the excitement of hashish would be necessary to give them a chance of revival. On the other hand, there are sensations with a force of revival which nothing destroys or decreases. Though, as a rule, time weakens and impairs our strongest sensations, these reappear entire and intense, without having lost a particle of their detail, or any degree of their force. M. Brierre de Boismont,* having suffered when a child from a disease of the scalp, asserts that "after fifty-five years have elapsed he can still feel his hair pulled out under the treatment of the *skull-cap*."—For my own part, after thirty years, I remember feature for feature the appearance of the theatre to which I was taken for the first time. From the third row of boxes, the body of the theatre appeared to me an immense well, red and flaming, swarming with heads; below, on the right, on a narrow floor, two men and a woman entered, went out, and re-entered, made gestures, and seemed to me

* Brierre de Boismont, op. cit. 376.

like lively dwarfs: to my great surprise, one of these dwarfs fell on his knees, kissed the lady's hand, then hid behind a screen; the other, who was coming in, seemed angry, and raised his arm. I was then seven, I could understand nothing of what was going on; but the well of crimson velvet was so crowded, gilded, and bright, that after a quarter of an hour I was, as it were, intoxicated, and fell asleep.

Every one of us may find similar recollections in his memory, and may distinguish in them a common character. The primitive impression has been accompanied *by an extraordinary degree of attention*, either as being horrible or delightful, or as being new, surprising, and out of proportion to the ordinary run of our life; this it is we express by saying that we have been strongly impressed; that we were absorbed, that we could not think of anything else; that our other sensations were effaced; that we were pursued all the next day by the resulting image; that it beset us, that we could not drive it away; that all distractions were feeble beside it. It is by force of this disproportion that impressions of childhood are so persistent; the mind being quite fresh, ordinary objects and events are surprising. At present, after seeing so many large halls and full theatres, it is impossible for me, when I enter one, to feel swallowed up, engulfed, and as it were, lost in a huge dazzling well. The medical man of sixty, who has experienced much suffering, both personally and in imagination, would be less upset now by a surgical operation than when he was a child.

Whatever may be the kind of attention, voluntary or involuntary, it always acts alike; the image of an object or event is capable of revival, and of complete revival, in proportion to the degree of attention with which we have considered the object or event. We put this rule in practice at every moment in ordinary life. If we are applying ourselves to a book, or are in lively conversation, while an air is being sung in the adjoining room, we do not retain it; we know vaguely that there is singing going on, and

that is all. We then stop our reading or conversation, we lay aside all internal pre-occupations and external sensations which our mind or the outer world can throw in our way; we close our eyes, we cause a silence within and about us, and, if the air is repeated, we listen. We say then that we have listened with all our ears, that we have applied our whole minds. If the air is a fine one, and has touched us deeply, we add that we have been transported, uplifted, ravished, that we have forgotten the world and ourselves; that for some minutes our soul was dead to all but sounds.—And, in fact, there are numerous examples in which, under the empire of a ruling idea, all other sensations, however violent, are annihilated; such, for instance, is the story of Pascal, who one night solved the problem of the cycloid, to distract his mind from violent pain in the teeth; that again of Archimedes, who, in tracing geometrical diagrams, was unconscious of the storming of Syracuse. Such also are the frequent and well-proved instances of soldiers, who, in the excitement of action, do not notice their wounds, and those of ecstatics, of somnambulists, and of hypnotised persons.—These authentic instances, and these metaphors of language, all bring to light the same fact, that is to say, the more or less complete and universal cancelling of all sensations, images, or ideas in favour of a single one; this last one being persistent and absorbing, produced and prolonged with an energy usually dispersed over several. In other words, we are set up for a time in a fixed and determinate form; the contrary solicitations, the different tendencies which result in another state, the other images, ideas, and sensations which are striving for production, remain in an incipient and abortive state. The given form is incompatible with them, and checks their development. What happens in us is just what takes place in a solution when a crystal is formed; the particles which had no affinity for any special structure now place themselves in a mass in fixed order; their unstable equilibrium is followed by a stable equilibrium whose rigid and precise direction resists the different agitations of the air and the fluid.

This exclusive momentary ascendancy of one of our states of mind explains the greater durability of its aptitude for revival and for more complete revival. As the sensation revives in the image, the image reappears with a force proportioned to that of the sensation. What we meet with in the first state is also to be met with in the second, since the second is but a revival of the first. So, in the struggle for life,* in which all our images are constantly engaged, the one furnished at the outset with most force, retains in each conflict, by the very law of repetition which gives it being, the capacity of treading down its adversaries; this is why it revives, incessantly at first, then frequently, until at last the laws of progressive decay, and the continual accession of new impressions, take away its preponderance, and its competitors, finding a clear field, are able to develope in their turn.

A second cause of prolonged revivals is repetition itself. Every one knows that to learn a thing we must not only consider it attentively, but consider it repeatedly. We say as to this in ordinary language, that an impression many times renewed is imprinted more deeply and exactly on the memory. This is how we contrive to retain a language, airs of music, passages of verse or prose, the technical terms and propositions of a science, and still more so the ordinary facts by which our conduct is regulated. When, from the form and colour of a currant jelly, we think of its taste, or when tasting it with our eyes shut, we imagine its red tint and the brilliancy of a quivering slice, the images in our mind are brightened by repetition. Whenever we eat, or drink, or walk, or avail ourselves of any of our senses, or commence or continue any action whatever, the same thing happens. Every man and every animal thus possesses at every moment of life a certain stock of clear and easily reviving images, which had their source in the past in a confluence of numerous experiences, and are now fed by a flow of renewed experiences. When I want

* "Struggle for Life" (Darwin). We shall see later on the development of this doctrine. The theory of the great English naturalist is nowhere more precisely applicable than in psychology.

to go from the Tuileries to the Panthéon, or from my study to the dining-room, I foresee at every turn the coloured forms which will present themselves to my sight; it is otherwise in the case of a house where I have spent two hours, or of a town where I have stayed three days; after ten years have elapsed the images will be vague, full of blanks, sometimes they will not exist, and I shall have to seek my way or shall lose myself.—This new property of images is also derived from the first. As every sensation tends to revive in its image, the sensation twice repeated will leave after it a double tendency, that is, provided the attention be as great the second time as the first; usually this is not the case, for the novelty diminishing, the interest diminishes; but if other circumstances renew the interest, or if the will renovates the attention, the incessantly increasing tendency will incessantly increase the chances of the resurrection and integrity of the image.

III. These are but the general conditions of revival; we obtain them by comparing an image taken at any point of its existence with another image at any point of its existence. We have now to compare two adjoining moments in the same mind, and to determine the more special conditions which excite at any time the birth of one image rather than of another.—For this, let us consider, not only isolated sensations, but also series of sensations. These have a similar tendency to revival, and the law which is applicable to the elements is also applicable to the compounds. On some days, without wishing it, we pass over in our mind some portion of our life, such as a day's travel, some evening at the opera, some interesting conversation. We feel ourselves brought back in a fixed manner to a former state; the ideas which attempt to throw themselves in the way are unwelcome; they are driven out, or rest on the threshold; if, at the first moment, some gap was found in our recollection, it usually ends by supplying itself; a forgotten detail rises unexpectedly.—I recollect at this moment an evening spent at Laveno on the Lago Maggiore, and as I dwell on it, I see my dinner at the inn, the coarse white

eloth, the pretty startled servant; then, a moment after, the path winding among thyme and lavender, the greyish-blue lake under its moist eloud of vapour, the patches of light, the glittering traeks, the sprinkled silver seales whieh a stray sunbeam had embroidered in plaees on its level sheet, the impereeptible rustling made by the little waves on the shore, and the bells of the eows tinkling here and there in the silence. All the prominent points in the group of sensations I then had, reappear in turn or together.—If now, taking one of these points, I inquire how it emerged, I find that it was *when it had already commenced to emerge.* For instanee, when I have reealled the winding lines of the path, and imagine myself turning to the left, I reeall the slate-eoloured lake and its embroidery of shining spangles, and above, the peaked mountains deseending in green slopes to the water; I find that the extreme edge of the bank borders the lake, the uniform surfaee is striped with brilliant fringes, and on the other side, the water rejoins the meadows and rising slopes; thus, the extremity of one image eoineides with the eommeneement of the next, and so the latter begins to revive as the first disappears. In the same way, the murmur of the tiny waves and the tinkling of the bells revert to me when my visual images are those of the lake and the bank; a eommeneement of imaginary sound aeeompanied the imaginary eoloured forms; it disengages itself, and we feel it reprodueed with all its shades, and up to its end. The partial revival results in a total revival.—This is so true that if, upsetting the natural tendeney of the images to revert in the order of the sensations, I attempt to reproduee the series inversely, I am able to eall up the former sensations from the latter ones as soon as I ean hit on the point of eontact in whieh they touch the ones they have followed. In faet, if I now traee baekwards up to my arrival at the inn, I see again the old oak some twenty paces from the house, two or three trunks of felled trees, and a dozen vagabonds strolling about or sleeping in the warmth of the evening sun; thus by calling up the point of eontaet, that is to say, the com-

meneement of the image, I supply to the image the means of reviving as a whole.—In fact, to speak correctly, there is no isolated and separate sensation. A sensation is a state which begins as a continuation of preceding ones, and ends by losing itself in those following it; it is by an arbitrary severing, and for the convenience of language, that we set it apart as we do; its beginning is the end of another, and its ending the beginning of another. By force of the general law which connects it to the image, its image has the same properties as itself; therefore this image itself arouses at its earlier extremity the ending of another image, and at its later extremity the commencement of another image, in such a way that the precedents and consequents of the sensation have also indirectly their echo in the image of the sensation.

Further than this, as different sensations are often similar in part, as soon as the image of one among them appears, the images of the others partially appear. When just now I was describing the sparkling streaks which the sun made on the water, I compared them to embroidery, to fringes, and to spangles of silver; the portion common to these four sensations, present in the first, successively revived the three others. Here again, the partial revival has resulted in a total revival.—We have often a difficulty in observing this partial revival. It seems to us, at the first glance, that such an idea has arisen involuntarily and by chance; we cannot see how it is connected with the foregoing one. This results from the idea which seems to have immediately preceded it, not having really done so; there were intermediate stages between them, which habit, inattention, or the speed of the operation, have prevented our observing; these intermediate stages have served for an invisible transition, and it has been through them that the law of Contiguity, or the law of Similarity, has applied. Hobbes, one of the first originators of this theory, relates* how, in the midst of a conversation on the English civil war, some one suddenly asked

* "Leviathan," part i. ch. 3, vol. iii. p. 12 (Ed. Molesworth).

what was the value, under Tiberius, of the Roman penny; an abrupt question seemingly unconnected with what had gone before. There was, however, a connexion, and with a little thought he recovered it. The English civil war, under Charles the First,—Charles the First delivered up by the Scotch for 200,000*l.* sterling,—Jesus Christ similarly betrayed for thirty pence under Tiberius. These were the links of the chain which led the speaker to his remarkable inquiry.*—We see now how the celebrated laws governing the association of images, and consequently that of ideas,† are reduced to a more simple law. What excites at any moment a particular image rather than any other, is a commencement of the revival; and this revival has already commenced, either *by similitude,* from the anterior image or sensation containing a portion of the reviving image; or *by contiguity,* from the anterior image becoming confused at its end with the commencement of the reviving image. Given any image at any particular moment, we can always explain its actual presence by its commencement of revival in the preceding image or sensation; and its clearness, force, aptitude for revival and other intrinsic qualities, by the amount of attention it has received, and number of revivals it has undergone, either in itself or in the corresponding sensation. All, it will be observed, comprised in our fundamental law, which discovers the tendency to revival in the sensation and in its image, and which, therefore, assures to the commenced image, to the image accompanied by

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* "An instance of this occurs to me with which I was recently struck. Thinking of Ben Lomond, this thought was immediately followed by the thought of the Prussian system of education. Now, conceivable connexion between these two ideas in themselves, there was none. A little reflection, however, explained the anomaly. On my last visit to the mountain, I had met upon its summit a German gentleman, and though I had no consciousness of the intermediate and unawakened links between Ben Lomond and the Prussian schools, they were undoubtedly these,—the German,—Germany,—Prussia,—and, these media being admitted, the connexion between the extremes was manifest."—Sir W. Hamilton, "Lectures," &c., i. p. 353.

† See Bain, "Senses and Intellect." He derives all the operations of the intellect from these two laws. See also Mervoyer, "Étude sur l'Association des Idées" (1864).

attention, and to the image strengthened by repetitions, a preponderance which results in its revival.

IV. The same laws explain the opposite event; by suppressing or weakening the conditions which increase an image's chance of revival and preponderance, we suppress its chances of ascendancy and revival.—In the first place, all that lessens the attention lessens these chances. Every minute we experience twenty sensations, of heat, cold, pressure, contact, muscular contraction; slight sensations like these are being incessantly produced in all parts of our bodies; in addition to this, sounds, murmurings, and hummings, are constantly going on in our ears; a number of little sensations of smell and taste arise in our noses and throats; but we are otherwise engaged—we are thinking, meditating, talking, reading—and during all this time we neglect other things. As regards other sensations, we are as if asleep or in a dream; the ascendancy of some dominant image or sensation keeps them in a nascent state. If, at the end of a minute, we attempt to recall them by memory, they do not revive; they are like seeds sown by the handful, but which have not grown; some single one, more lucky, has monopolized to itself all the room and nutriment the earth affords.—It does not necessarily follow that these sensations, destined to obliteration, are feeble ones; they may be powerful ones: it is sufficient that they should be weaker than the privileged one. A musket-shot, the flash of a cannon, a painful wound, frequently escape attention in the heat of battle, and, not having been observed, cannot revive; a soldier suddenly finds he is bleeding, without being able to recollect the blow he has received.—In nine cases out of ten, and perhaps in ninety-nine out of a hundred, the sensation loses in this manner its power of revival, because there cannot be attention without distraction, and the predominance acquired by one impression is a predominance taken from the others. Here again, things are, as it were, in a balance; one scale can only rise by lowering the other, and the lowering or elevation of the one is in proportion to the elevation or lowering of the other.

On the other hand, the want of repetition also diminishes the chances of revival. Every one knows that we forget many of the words of a language when we have given up reading or speaking it for many years. So it is with an air we no longer sing, with a piece of verse we no longer recite, with a neighbourhood we have been long absent from. Breaks occur in the train of recollections, and go on increasing like the holes in an old garment.—We have no difficulty in seeing how continuous and vast these destructions must be; every day we lose some of our recollections, three-fourths of those of the preceding day, then others among those surviving from the previous month, so that before long a whole month, or even year, is only represented in our memory by certain prominent images, like those few peaks still appearing in a submerged continent, destined, at least the most of them, themselves to disappear, since the gradual obliteration is owing to a continuous flood, invading one by one the untouched crags, and sparing nothing but a few rocks uplifted by some extraordinary circumstance to a height no wave can reach. In fact, very few of our sensations, even of those accompanied by attention, are often repeated. Six months ago I was talking to such a person; after I left him, and even on the following day, I could have described his appearance and dress, have repeated the principal topics of conversation; but since then I have not renewed in experience or repeated in memory the images which then revived in me, intact and connectedly. They are obliterated, and now, when by chance I find some fragment of the distant scene, and stop to call up the rest, my efforts are vain.—So it happens with nearly all the portions of our experience: the impression received has been a solitary one; in a thousand such, there is at most one which is twice repeated; in a thousand of the repeated ones, there is scarcely one which is repeated twenty times. Some few only—those of permanent objects surrounding us—of some twenty or thirty persons, pieces of furniture, monuments, streets, landscapes, derive from constant repetition a multiplied aptitude for revival. With the others, the aptitude

is too weak; when a fragment of distant experience, with which they were formerly connected, reappears, they do not reappear with it; the tendency which formerly called them up is vanquished by other tendencies formed in the meanwhile; and the recent past blocks up the way of the earlier past.

Finally, on the other hand, images grow dull by repetition, as bodies are worn away by friction. If we see a person eight or ten times, the outline of his form and expression of his face become at last much less clear in our mind than on the day after we have first seen him. So it is with a monument, a street, a landscape, when seen many times at different hours of the day, at evening, in the morning; on a dull day, in rain, under a bright sun, if we compare them with the same monument, landscape, or street, watched for three minutes, and then replaced by some entirely different object. The impression, so precise at first, becomes less so the second time. When I imagine the monument, I find indeed the outline, which has remained constant all the time, but the distribution of light and shade, the changing nature of the tones, the look of the grey or blackened pavement, the band of sky above—greyish and misty in the one case, dark and tarnished in the other; sometimes a bright white, sometimes a dark purple—in short, all the diversities which at different moments have connected themselves with its permanent form, are mutually annulled. And so, when I think of a person I know, my memory wavers between twenty different expressions, smiling, serious, unhappy, the face bent on one side or the other. These different expressions form obstacles to each other; my recollection is far clearer when I have only seen him for a minute—when, for instance, I have looked at his photograph or picture.

In fact, when the image of the form we have perceived tends to revive, it draws with it the images of its several accompaniments. But these accompaniments being different cannot revive together; the features of the same face cannot be at once smiling and severe; the façade of the same palace cannot be at once of an intense black, as when the sun is setting behind it, and of a rosy brightness, as when it is

rising in front of it. Therefore, if these mutually exeluding accompaniments have an equal tendency to revive, neither one nor the other will do so, and we shall feel ourselves drawn in different directions by contrary tendencies which come to nothing; the images will remain in an inchoate state, and will make up what we call in ordinary language an *impression*. This impression may be strong without ceasing to be vague; beneath the incomplete image a dull agitation is going on, and as it were, a swarm of feeble impulses which usually sum themselves up in an expressive gesture, a metaphor, a visible summary. Such is our usual state as regards things we have many times experienced; a vague image, corresponding to a portion of our different experiences, a heap of contrary tendencies of nearly equal force, corresponding to their different circumstances, a clear notation, denoting and concentrating the whole in an idea.

This law of obliteration is of considerable extent, for it is applicable not only to different appearances of the same object, but also to different objects of the same class; and all the objects in nature may be grouped in classes. A man who has passed through an alley of poplars, and wishes to figure to himself a poplar, or who, after seeing a large farmyard, wishes to figure to himself a hen, experiences a difficulty. His different recollections encroach upon each other; the differences which distinguished the two hundred poplars or the hundred and fifty hens are mutually obliterated; he will preserve a more precise image if he has only seen a single poplar standing in a meadow or a single hen roosting in a shed.—All our images undergo a similar blunting; let the reader attempt to imagine a rabbit, a carp, a pike, a bull, a rose, a tulip, a birch tree, or any other object belonging to a numerous class and of which he has seen many individuals, and on the other hand, an elephant, a hippopotamus, a magnolia, an American aloe, or any other object of a small class, and of which he has only met with one or two specimens; in the first case the image is vague and all its surroundings have disappeared; in the second it is precise, and one is able to point out the spot in the Jardin des

Plantes, the Parisian Conservatory, the Italian villa, where the object was seen.—The multiplication of experience is then a cause of obliteration, and images, by annulling one another, thus fall into the state of dull tendencies hindered by their contrariety and equality from assuming an ascendancy.

V. Thus we arrive at a general conception of the history of images, and, consequently, of ideas in a human mind. Every sensation, weak or strong, every experience, great or small, tends to revive by means of an internal image which repeats it, and is itself capable of repeating, even after long pauses, and this indefinitely. But as sensations are numerous, and are at every moment replaced by others, without truce or termination, up to the end of life, there is a conflict of preponderance between these images, and, though all tend to revive, those alone do so, which have the prerogatives required by the laws of revival; all the others remain incomplete or null, according to the laws of obliteration.—By force of this double law, groups of efficacious aptitudes are constantly becoming inefficacious, and images are falling from the state of actual to that of possible existence. Thus, human memory is like a vast reservoir, into which daily experience is continually pouring different streams of tepid waters; these waters being lighter than the others rest on the surface and cover them; then growing cold in their turn, they descend to the bottom by portions and degrees, and it is the last flow that constitutes the new surface. Sometimes a particular stream, from being swollen or having a higher fall, warms ancient inert layers below, and then they remount to the light; the chance of the flow and the laws of equilibrium have warmed a certain layer so as to place it above the rest. The shape of the reservoir, the accidents of temperature, the various qualities of the water, sometimes even shocks of earthquake, all bear part in this; and many authentic instances show us deep layers uplifted suddenly and entire to the surface, sometimes superficial layers plunged suddenly and entire below.

In fact, images have, as we shall see later on, certain states of brain as conditions of their being; hence, we

understand how an injury, a rush of blood, a deterioration of blood, any change of the cerebral substance, may hinder or promote the arising of certain groups of images. "I descended on the same day," says Sir Henry Holland,* "two very deep mines in the Hartz mountains, remaining some hours underground in each. While in the second mine, and exhausted both from fatigue and inanition, I felt the utter impossibility of talking longer with the German inspector who accompanied me. Every German word and phrase deserted my recollection, and it was not until I had taken food and wine, and been some time at rest, that I regained them."—Similar mischances are not uncommon after brain fevers or great losses of blood. A lady, says Winslow,† after large uterine hæmorrhage, "had forgotten where she lived, who her husband was, how long she had been ill, the names of her children, and even her own name. She was unable to give anything its real name, and in attempting to do so, made the most singular mistakes. She had been accustomed, before her illness, to speak French instead of English. But afterwards she seemed to have lost all knowledge of French; for, when her husband addressed her in that language, she did not appear to understand what he said the least in the world, though she could converse in English without difficulty." After seven or eight weeks these blanks in her memory began to be restored; and after some months they were entirely filled up. So a gentleman, mentioned by Abercrombie, "after a blow on the head, lost his knowledge of Greek, and did not appear to have lost anything else."‡—The loss occasionally attaches to some period of former life. "A clergyman, on recovering from an apoplectic attack, was found to have lost the recollection of exactly four years; everything that occurred before that period he remembered perfectly. He gradually recovered."§ Another patient, who had been

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* "Chapters on Mental Physiology," p. 167, n. cited by Winslow, "Obscure Diseases," &c., p. 252.

† Winslow, ibid. p. 344.

‡ "Inquiry into the Intellectual Powers," p. 152. § Ibid. p. 151.

for some ten or twelve years in Edinburgh, recollected nothing of that period of his life; on the contrary, the earlier portion, which had been passed in another country, was well remembered by him.—Lately, a celebrated Russian astronomer forgot, in turn, the events of the previous day, then those of the year, then those of the years last past, and so on, the chasm gradually increasing, till at last he could only recollect the events of his childhood. His case was considered hopeless; but by a sudden stop and unforeseen return, the blank filled up in an inverted manner; the events of his youth first reappearing, then those of his manhood, and finally, the more recent, those of the previous day. His memory was wholly restored at the time of his death.

Gradual recoveries like these have also been observed after violent falls; and the fissure in the memory closes up sometimes from one end, sometimes from the other. "Some years ago," says Abercrombie,* "I saw a boy who had fallen from a wall, and struck his head against a stone which lay at the foot of it. He was carried home in a state of insensibility, from which he soon recovered, but without any recollection of the accident. He felt that his head was hurt, but he had no idea how he had received the injury. After a short time he recollected that he had been on the top of a wall, and had fallen from it and struck against the stone, but could not remember where the wall was. After some time longer, he recovered the recollection of all the circumstances." Others when injured forget the accident only, and not the circumstances; others the circumstances only, but not the accident.—Sometimes the alteration is still stranger, and affects a certain class of associations only. "A lady,† after an apoplectic attack, recovered correctly her ideas of things, but could not name them. In giving directions respecting family matters, she was quite distinct as to what she wished to be done, but could make herself understood only by going through the

* "Inquiry into the Intellectual Powers," p. 146. † Ibid. p. 149.

house, and pointing to the different articles.—A gentleman could not be made to understand the name of an object if it was spoken to him, but understood it perfectly when it was written. His mental faculties were so entire that he was engaged in most extensive agricultural concerns, and he managed them with perfect correctness by means of a remarkable contrivance. He kept before him in the room where he transacted business, a list of the words which were most apt to occur in his intercourse with his workmen. When one of these wished to communicate with him on any subject, he first heard what the workman had to say, but without understanding him further than simply to catch the words. He then turned to the words in his written list, and whenever they met his eye he understood them perfectly."*

This suppression of ordinary aptitudes explains the revival of lost aptitudes. One particular new organic disposition may be unfavourable to the first; and so, some other new organic disposition may be favourable to the second. The first cease to be active, like a nerve suddenly paralysed; the second become active again, like a paralysed nerve suddenly electrified. We have seen an instance of this in the case of the ignorant young girl who, in her delirium, recited

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* See other analogous facts in the "Dictionnaire d'Histoire Naturelle," published by M. Guérin, in an article by Grimaud de Caux.—(Duval Jouve, "Logique," p. 159.)

"A man of sixty, in good health, who had had an ulcer in his leg for a considerable time, permitted it to become closed. Before long he had a slight attack of apoplexy, and this was followed by a loss of memory, first of certain words, then of the French language. The remarkable thing was that he recollected perfectly the Piedmontese language.

"A man of science on starting for Greece was thrown out of his carriage; a box, fortunately not a very heavy one, fell on his head; he suffered no pain, and the skin was not broken; but he completely forgot where he had come from, the object of his journey, the day of the week, the dinner he had just made, and all his acquired knowledge. In fact, he had forgotten the names of his relations and friends, and could only recall his own, those of his children, and the symbol of the Trinity. He was replaced in the carriage, in order that assistance might be obtained, and, after half an hour's jolting over a stony road, suddenly recovered himself."

Page 162—"Some persons forget proper names; others, like Doctor Broussonnais, substantives. Dietrich tells the story of a man who, while recollecting facts, had forgotten half his words. There are instances of foreign languages, the facts of history, dates, &c., being entirely forgotten, while other things were recollected."

passages of Greek and rabbinical Hebrew; in the servant who, when seized with fever, spoke Welsh, which, when well, she did not understand. "A man," says Abercrombie, "born in France, had spent the greater part of his life in England, and for many years had entirely lost the habit of speaking French. When under the care of Mr. Abernethy for an injury of the head, he always spoke French."* In other cases a similar revival as to other languages has been observed. "An eminent medical friend," says the same author, "informs me that during fever, without any delirium, he on one occasion repeated long passages from Homer, which he could not do when in health." Another person, who, when well, had no capacity for music, and had almost forgotten the Gaëlic language, sang, during an illness, Gaëlic songs, and that with great precision, though the melody was a difficult one, and he had previously been utterly incapable of singing it.

Let us now conceive the existence in the same person of two distinct states, such as we have been describing; let us suppose that in the first a certain group of images, in the second, some other group, can alone revive, what will happen if in the two states the general organic disposition is different, and if this difference is a clearly marked one? The individual will have two memories, the first recalling only the events of the first state, and the second recalling only the events of the second state.† A young American lady, says Macnish,‡ after a prolonged sleep, lost the recollection of all she knew. She was obliged to learn again how to spell, to read, to write, to calculate, and to know the persons and objects around her. A few months after,

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* Abercrombie, op. cit. 140, 142.

† "When people have been twice hypnotised, we find that they forget completely when they wake the acts and thoughts artificially produced, and recover perfect recollection of them on re-entering the artificial state. Mr. Braid mentions having seen intelligent persons who could recollect exactly and minutely all that had happened during a state of sleep six years before, and who narrated this whenever they were hypnotised, while, when awake, they had no recollection of it."—"De la Folie Artificielle," Dr. Tuke, "Annales Médico-Psychologiques," 4e Série. vi. p. 271.

‡ Macnish, p. 113, n. citing from "The Medical Repository." New York.

she was again seized with a deep sleep, and when she woke she was restored to the state she was in before the first sleep, having all the knowledge and recollections of her youth; but on the other hand, having entirely forgotten all that had passed between the two attacks. "During four years and upwards she has passed periodically from one state to the other, always after a long and sound sleep. . . . . The former condition of her existence she now calls the Old State, and the latter the New State; and she is as unconscious of her double character as two distinct persons are of their respective natures. For example, in her old state she possesses all the original knowledge; in her new state only what she acquired since. If a lady or gentleman be introduced to her in the old state, or *vice versâ* (and so of all other matters), to know them satisfactorily she must learn them in both states. In the old state, she possesses fine powers of penmanship, while in the new, she writes a poor awkward hand, not having had time or means to become expert. Both the lady and her family are now capable of conducting the affair without embarrassment. By simply knowing whether she is in the old or new state, they regulate the intercourse, and govern themselves accordingly."— This double life is often found in somnambulists.* The majority of them forget on awaking all they have done in their sleep, and are surprised to find themselves out of bed or in the street. But this forgetfulness frequently ceases on a second attack. "The somnambulist," says M. Maury, "takes up again the chain of ideas interrupted while he was awake. Thus Dr. Mesnet's patient carried out, during an attack, projects of suicide she had conceived in a previous attack and forgotten during the lucid interval; in the second attack she recalled all the circumstances of the first. M. Macario has cited a very significant example of a young girl who was violated during a fit of somnambulism,

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* Maury, "Du Sommeil," 210. Todd, "Cyclopædia," Article "Sleep." Puel, "Mémoire sur la Catalepsie."

and who, on awaking, had no recollection or consciousness of what had happened. It was only in a new fit that she related to her mother the outrage committed upon her." In these two instances, the wakeful state only recalled the wakeful state; the state of somnambulism only recalled the state of somnambulism, and each of the two alternate lives formed a separate whole.

Correspondences and separations like these, but partial and temporary, are met with in ordinary life. "Mr. Combe mentions the case of an Irish porter to a warehouse, who, in one of his drunken fits, left a parcel at the wrong house, and when sober could not recollect what he had done with it; but the next time he got drunk, he recollected where he had left it, and went and recovered it."* M. Maury again mentions cases of dreams forgotten when awake, and recalled in a new state of sleep.—On the other hand, our ordinary memory recalls only half our states. We recall our thoughts of yesterday, but not those of the night while we were asleep; however vivid they may have been, even when they have provoked actions or the beginnings of actions, cries, gestures, and all that an uneasy man does in his sleep, it is very unusual for us to be able on waking to recover any portions of them.† It is a strange thing, we start from an intense dream, full of emotions; and it would seem that so violent a state ought to be easily reproduced, even after a considerable time. Not at all; after two or three minutes the objects so clearly perceived die away in clouds; and these clouds vanish; half an hour afterwards I shall be scarcely able to relate my dream; if I want to remember it later on, I am obliged to write it down at once.—The fact is that the physiological state and the circulation of blood in the brain are not alike in sleep and when awake, and the second state, favourable to the recall of its own images, is not favourable to the recall of the images of the first state.

But whatever be the phenomenon, rudimentary and normal,

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* Macnish, ibid. p. 55, n.

† Macnish, ibid.

or abnormal and complete, it shows how our images, by connecting themselves, make up the group which in literary and judicial language we call the moral personality. If two groups are distinctly severed, so that no element of the one calls up any element of the other, we shall have, as in the case of the lady cited by Macnish, two moral personalities in the same individual. If in one of the two states the images have exact and delicate associations, if, as we see in the cases of many somnambulists,* superior aptitudes show themselves, if, as we observe in drunkenness and after many illnesses, the passions take another degree and another direction, not only will these moral personalities be distinct, but there will be enormous disproportions and contradictions between them.—No doubt, though among somnambulists, persons hypnotised and in states of ecstasy, similar contrasts distinguish the ordinary from the abnormal life, these two lives are not clearly nor entirely distinct; some images of the one always, or nearly always, introduce themselves into the other; and, when man is concerned, the supposition we have made remains simply a conception of the mind.—But, among animals, we meet with instances in which it is exactly applicable; such as that of the batrachians, and of insects which undergo metamorphoses. Their organization and nervous system bring forward in turn, by their transformations, two or three moral personalities in the same individual: in the chrysalis, the larva, and the butterfly, instincts, images, recollections, sensations, and appetites, are all different; the silkworm which spins, and its moth which flies, the voracious larva of the cockchafer, with its terrible apparatus of stomachs, and the cockchafer itself, are two distinct states of the same being at two epochs of its development, two distinct systems of sensations and images engrafted on two distinct forms of the same nervous substance.—If a sleep like that of the chrysalis were to overtake us in the midst of our life, and if we were to awake with an organization

* Maury, ibid. p. 125.

and a nervous machinery as much transformed as that of the worm which has become a butterfly, the break between our two moral personalities would evidently be as great in our case as with it.—The reader can now see the infinite consequences of that property of our sensations and images which we have termed aptitude for revival; it assembles in groups our internal events, and in addition to the continuity of physical being constituted by permanence of form, it constitutes, by the return and connexion of images, the continuity of the moral being.

BOOK III.

OF SENSATIONS.

CHAPTER I.

OF SENSATIONS OF HEARING AND THEIR ELEMENTS.

I. By reduction upon reduction we have arrived at a fact, primitive and apparently irreducible, of which all the rest, whether images or ideas, are but repetitions more or less transformed and disguised. I mean sensation, and before defining it, that is to say, before showing its nature, we must first describe it, that is, must distinguish it and bring it to light, from among the heap of facts in which it is comprised.—When a cutting instrument is plunged into our flesh, we feel pain, and this pain, taken by itself and alone, is a sensation strictly so-called. There are a number of such facts, similar in nature, though differing in kind and degree; such are the sensations of contact, of pressure, of tickling, usually excited in us when an external body touches, in a particular way, certain portions of our bodies; such are the sensations of temperature produced when a certain degree of heat is added to or taken away from our ordinary temperature; such are the sensations of muscular activity, so called from their apprising us of the tension or relaxation of our muscles; such, in short, are the sensations excited in us by the particular juices of an object we taste, by the volatile particles of an object we smell, by the vibrations of the air which strike our organs of hearing, by the vibrations of light which strike our organs of sight, and which we commonly call sensations of taste, of smell, of sound, and of colour.

Many of these names are ambiguous, and the words taste, smell, sound, colour, heat, sometimes denote a property, more or less unknown to us, of surrounding bodies, of liquid or volatile particles, of vibrations of the air or of light; sometimes, the well-known kind of sensations which these bodies, particles, and vibrations, excite in us. But the distinction is easily made; for the property appertains to the object and not to us, while the sensation appertains to us and not to the object. Lemon-juice has an acid taste; this means that it possesses an unknown property of exciting in us a well-known sensation, that of an acid taste. This sheet of paper is white: this means that by virtue of its particular texture, this sheet of paper, when in the light, excites in us the sensation of the colour white.—Two other distinctions less readily made are no less necessary. When we experience a sensation, we localize it; we refer such a pain, such a feeling of heat, such a sensation of contact, to the hand, to the leg, to such-and-such a part of the body, such a sensation of smell to the interior of the nose, such a sensation of taste to the palate, to the tongue, to the back of the mouth. But, as we shall see later on, there is here an ulterior operation engendered by experience; a group of images has combined with the sensation to attribute to it this position; this group gives it a situation which really it has not, and, in general, places it at the extremity of the nerve whose action excites it. Sometimes again, a second operation removes it to a still more distant place; sounds and colours, which are sensations only, at present appear to us situated, not in our organs, but at a distance, in the air, or on the surface of external objects; the reader will see, when we examine external perception, how the education of the senses produces this apparent recoil. Meanwhile, to understand the sensation properly, we must separate it from this accompaniment, must lay aside the appendages which time has attached to it, and consider it in its simple primitive state.—Finally, we must distinguish it, at least provisionally, from the state of the nerve and nervous centres by whose action it is produced. It is true that this

state is the sufficient and necessary condition of the sensation, but their identity is not clear; at first sight they differ, and certainly are not known to us to the same extent or in the same way. For the sensation is perceived directly, completely, and at once, but the action of the nervous system is proved indirectly, incompletely, and very slowly; an infinite amount of anatomical and physiological research was required to teach us that the sensation depended on it; even now we are wholly ignorant of what it consists, whether it is a propagated vibration, an electric current, a chemical change, or what else it may be. Strict method then requires us, for the present, to leave it on one side and to study in the first place the sensation apart.—So circumscribed, it is that primary internal event, directly known to us, accompanied by images associated with it and localizing it, and excited by a certain state of the nerves and nervous centres, a state unknown to us, and consequent, in general, on the action of external objects.

II. Here we have a fact of supreme importance; for its diversities and arrangements form the material of all our knowledge. When we consider closely any one of our conceptions—that of a plant, an animal, a mineral—we find that the primitive threads of which it is woven are sensations, and sensations only; we shall see the proof of this later on. But we have it already, if we recollect that our images are only reviving sensations, that our ideas are nothing more than images which have become signs, and that thus this elementary tissue subsists, in a more or less disguised form, at all stages of our thought.—These primitive threads are of different kinds. Sensations have long been, more or less happily, distributed, in the ordinary method, into classes and sub-classes; first, according to the services they render us; then, according to the particular circumstances in which they arise, and the parts in which the associated images induce us to place them; and lastly, according to such rough similarities as internal observation can find in them *—A first group has been formed of those

* Gerdy, "Physiologie des Sensations et de l'Intelligence." Bain, "Senses and Intellect," 87, 250.

which denote different states of the body in health or sickness, and are stimulants to action, rather than elements of knowledge; these have been called sensations of organic life, and have been divided into genera and species, according to the organs or functions which excite them; in one class, effort, fatigue, and the different pains occasioned by states of the muscles, bones, and tendons; in another, nervous exhaustion, and the nervous sufferings occasioned by special states of the nerves; in another, the sufferings of thirst and hunger occasioned by certain states of circulation and nutrition; in another, suffocation and the peculiar state of uneasiness occasioned by a certain state of the respiration; in another again, sensations of cold and heat occasioned by a general state of all the organs; finally, in another, those, as of digestion, occasioned by states of the alimentary canal.—By the side of this group a second has been formed, whose earlier classes come in contact with the latter ones of the first group; it comprises those sensations which do not acquaint us with the healthy or unhealthy states of our bodies, but are elements of knowledge, rather than stimulants to action. These we call sensations of intellectual life, and divide them, according to the special organs exciting them, into sensations of smell, of taste, of touch, of hearing, and of sight. In each of these genera there are species. In sensations of taste, distinctions are drawn between relishes* allied to alimentary sensations, and provoking appetite or disgust, according to the state of the stomach, and tastes strictly so called, and themselves divisible into many groups, such as bitter, sweet, salt, alkaline, acid, astringent. In sensations of smell, distinctions are similarly drawn between smells connected with the respiratory sensations, compounded or mingled with a sensation of freshness or closeness, and smells strictly so called, and themselves divisible into perfumed, fœtid, pungent, ethereal, &c. Similar classifications are adopted in the distribution of the sensations of the other senses; and slight

* *Relishes* distinguished from *tastes*.—Bain, "Senses and Intellect."

differences will be found in them, according to different authors.*

But these differences are of little importance; all they afford us is a survey of the subject; we have constructed a convenient repository, with compartments enabling us to lay our hands readily on the sensation we wish to consider; but this is all. We do not know what the sensation itself consists in; if we consider some particular one—for instance, the smell of a rose—we find it comprised in the class of perfumed odours with that of the lily, the violet, musk, and an infinite number more. But while thus distinguishing it from others, we cannot say in what it differs from them; we vaguely perceive that it is a stronger smell than that of the violet, and not so strong as that of the lily; our knowledge is reduced to this. We cannot enumerate and state its elements as precisely as if it were a question of two kinds of minerals or vegetables; we have no elements of comparison, like magnitude, form, position, number, to sum up and connect together; mathematical and geometrical qualities, which serve as a foundation for the physical sciences, fail us here.—And here, again, the ground from which we started to construct the moral sciences fails us also. We have not here those common elements, images, representations, general ideas, to which different human inventions and social combinations may be reduced. We are at the central point of knowledge, a kind of link placed between the infinite ramifications of the branch and those of the root, enclosing in its narrow band the origin of the fibres which above and below make up, by their multiplication and their arrangement, the entire plant.—But it is precisely because our sensations are elements of which all the rest is composed, that we are unable to decompose them like the rest; we cannot find elements of these elements. We are able to show how with them we form images, representations, and general ideas—how with them we form notions of magnitude, position, form, and

* See the physiological works of Longet, Mueller, Carpenter, Todd and Bowman, &c.

number; but as to how they are themselves formed, this we do not know.

It seems, then, that they escape from science; and, in fact, when we read works treating of them, we learn little but what we knew before; when we close the book, we find them well arranged in our mind, and that is all. If we are taught anything, it is in another department, in physiology and anatomy, by the knowledge of the apparatus, organs, and movements on which they depend. Even with the highest hopes, all the horizon shows us is a more extended knowledge of these apparatus, movements, and organs; perhaps some day, if the microscope becomes more powerful, when the theories of electricity, organic chemistry, and molecular physics have made some great advance, experimentalists may be able to distinguish the different primitive fibres in a nerve, may define exactly their internal movements, explain the structure of the nervous centres, and state precisely what change of state the action of the nerve excites there.—Under the most favourable circumstances, and supposing the science complete, we should arrive at a mathematical formula enabling us to sum up in some one law the different positions and relations of the nervous particles.—But these advances, great as we imagine them to be, add nothing to our idea of sensations; they enlighten us as to their conditions, but not as to them. If you describe to me the molecular movement produced in the glosso-pharyngeal nerves, and the other molecular movements consequently developed in the nervous centres when a solution of sugar or of colocynth passes over my tongue or throat; you will not teach me anything as to the nature of the sensations of sweet and bitter. I shall know the circumstances under which they arise, I shall not know their elements, or even if they have any. The most I shall perhaps find will be some law connecting the intensity of bitterness with some form or other of molecular movement, resembling the law which makes the acuteness of a sound increase with the number of vibrations transmitted to the auditory nerve.

The matter becomes still clearer when we compare two

sensations, not of the same, but of different senses, even when both are produced by the same external cause; for instance, the tickling and the sound produced by the same vibrations of the air, the painful feeling and luminous circle produced by the same compression of the eye, the sensations of dazzling light, of hissing sound, of shock, or tingling, produced by the same electricity applied to different senses. Each one of these senses forms a region apart; neither smell, nor taste, nor colour, nor sound, nor sensation of contact, can be reduced to any other; and, in every sense, there are many regions no less distinct from one another; bitter, salt, and sweet tastes, like blue, red, and yellow colours, like sensations of heat, pressure, and tickling, seem equally irreducible to one another.—The only intrinsic quality which we find to be common to all these distinct domains, is the degree of intensity; every sensation is capable of increase or decrease; it is a stage in a magnitude; smell, taste, sound, brightness, pressure, may all be more or less strong. So it is with the secondary groups comprised in the principal ones; every special sensation, that of bitterness, of tickling, of blue, has a maximum and a minimum, on passing which, it ceases, or becomes of another kind.—But each of them is a kind of simple body which, though capable in itself of increase or diminution, is not convertible into any of the others. In chemistry there are sixty-one such; there are many more for every sense, for instance, for smell or taste; for there is scarcely a single volatile odorous matter that does not form a type apart; we are sometimes able to arrange two, or at most three other sensations, together with the sensation it excites, as the smell of garlic and of the vapour of arsenic with the smell of tin; thus the species are innumerable, and classes scarcely exist; as we see on attempting to count the smells of perfumed plants in a garden, or of disagreeable gases in a laboratory.—Thus it would seem that at the commencement of psychology, we are obliged to set down a very great number of facts as mutually irreducible, just as simple bodies in chemistry, as the species of animals in zoology, or of vege-

tables in botany, but with this special disadvantage, that while in chemistry, in botany, and zoology, differences and resemblances are constituted by homogeneous and precise elements, number, force, and form, in the sensations, no such element can be isolated, and we are driven to the unreasoning affirmation of certain rough likenesses and to the dry statement of an indefinite number of undefinable differences.

III. Sensations, however, have elements, as will appear from various examples. We all know that in a musical chord there are two notes, that an ordinary colour is made up of many colours; we must advance a step, and see if those sensations of sound, colour, and the rest, which appear to us simple, are not themselves composed of more simple sensations.—Psychology is at present confronted with sensations professedly simple, just as chemistry was, at its outset, with professedly simple bodies. In fact, in its early stages, observation, whether internal or external, perceives compounds only; its business is to decompose them into their elements, to show the different groupings these elements are capable of, and to construct different compounds with them. The chemist shows that, by the combination of a proportion of nitrogen with one, two, three, four, or five, proportions of oxygen, we form protoxide of nitrogen, deutoxide of nitrogen, nitrous acid, hyponitric acid, and nitric acid; five substances which, to ordinary observation, have nothing in common, and which, nevertheless, differ only in the number of proportions of oxygen comprised in each of their atoms. The psychologist has to inquire whether, by combining such-and-such an elementary sensation with one, two, three, other elementary sensations, by approximating the times of their occurrence, by giving them a longer or shorter duration, by communicating to them a greater or less intensity, he cannot arrive at constructing those masses of sensation to which rude consciousness attains, and which, though irreducible to her, differ only in the duration, proximity, magnitude, and number of their elements.

Now there is a group of sensations in which a complete reduction can be effected—namely, those of hearing; and we may legitimately argue from these to others; the partial solution attained indicates a general solution which may be attained.—The kinds of sounds are apparently very numerous; and ordinary observation detects in them many seemingly simple qualities. Two sounds produced by the same instrument may be respectively high and low. Two sounds equally high or low have different tones, if produced, one by a violin, and the other by a flute. Two sounds equally high or low, and of the same tone, may be more or less loud or intense. Two sounds may be, the one musical, the other unmusical; that is to say, the one may be a continuous sensation, all whose parts are mutually alike; while the other is a discontinuous sensation, and made up of parts differing from one another. Finally, this last class contains many kinds apparently irreducible to one another; explosions, clangings, grindings, hummings, rustlings, which we can only denote by the body and external condition producing them, as the sound of a hammer, of a glass, of a piece of wood, of crumpled paper, &c.—In this great collection we distinguish two qualities capable of degrees—intensity, and acuteness; in these respects, different sounds form a scale; in all other respects, they are in juxtaposition, are vaguely related to one another, like smells and tastes, without it being possible to say in what this relationship consists; tone, for instance, like noise, is a thing undefinable. The same *sol* played with the same strength on a clarionet, a flute, a violin, a horn, a bassoon, borrows a special character according to the different instruments; it is more piercing on the violin, more brilliant on the horn, sweeter on the flute, keener on the clarionet, more veiled on the bassoon. But none of these adjectives define it; they only indicate some distant analogy between our total impression and impressions of another nature; they are simply literary labels like the names we apply to perfumes, when we call the smell of the heliotrope delicate, that of the lily, full and rich, of

musk, penetrating, &c. These epithets tell us something of our sensation, but very little; in no case do they tell us anything of the elementary sensations, of which our whole sensation is made up.

Fortunately, students of physics and physiology have advanced our researches while pursuing their own; and their discoveries as to undulations and the nerves enable us to find what we are seeking.—The sensation of sound is excited by the concussion of the acoustic nerve, occasioned, in most cases, by the vibration of the external air; we further observe, in fact, that when precisely similar concussions are occasioned, precisely similar sensations of sound are produced. This is the case with the sirens of Cagniard Latour and Helmholtz, and the wheel of Savart. When this wheel is turned at an uniform rate, its teeth, which are at equal distances, strike a bar in passing; and this regular succession of similar concussions excites a regular succession of similar sensations of sound. Now, while the wheel turns sufficiently slowly, the sensations, being discontinuous, are distinct; and each of them, being compound, is a sound. But when the wheel is set to turn fast enough, *a new sensation arises*, that of a musical note. It distinguishes itself from the remains of the noises which still go on and continue distinct, and stands out as a fact of a different kind; among the different elementary sensations which make up each sound, there is one which the operation has separated; and this now ceases to be distinct from *the similar elementary sensation* following in each of the succeeding sounds. *All these similar sensations now combine in one long continuous sensation;* their mutual limits are effaced; experience, just as in a chemical analysis, has extracted an elementary sensation from the complex group in which it was included, has joined it to an absolutely similar elementary sensation, and formed a new compound, the sensation of musical sound.*

* Mueller (tr. Baly), ii. 973 and 1298. The wheel of Savart shows us that a second elementary sensation is necessary and sufficient to effect this extraction and form the new compound.

But if, among musical sounds, we choose a very deep one, for instance, the lower octave of the organ, we see that the elementary sensations, though still forming a continuous whole—which they must do for the sound to be musical—nevertheless remain to a certain extent distinct. "The lower the note, the better does the ear distinguish in it the successive pulsations of the air."* It is then not much removed from a buzzing, that is to say, a simple noise. We distinguish in it elementary sensations; we recognise that each of them consists in a swelling and a dying away, that is to say, in an increase and a diminution of intensity; we can observe the limits of each one of them; these limits are but half effaced. We find, on comparing it with the elementary sensation corresponding to a more acute note, that it occupies a greater length of time. Again, the length of time is greater between the maximum of height of one of its elementary sensations, and the maximum of height of the succeeding one. The whole sensation is thus composed of larger molecules and more distant maxima. This is why we call it a fuller or heavier sound. Here we perceive the elementary sensation whose different combinations are sufficient to explain all the sensations of sound.

Let us first consider musical sounds. We know by acoustics that the condition of a sound being musical is that there be a uniform series of vibrations of the air; that each of these vibrations is of certain length, and lasts a certain fraction of a second; that the more it diminishes in length and duration, the more acute becomes the note. All analogies show that there are elementary sensations in this case, just as in that of the very deep note, and scientific experiment comes in to confirm these inductions.—Take a wheel with two thousand teeth revolving n a second; it gives two thousand blows in a second, and therefore two blows in the thousandth part of a second; if all the teeth except two adjoining ones are now removed, the two blows

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* Helmholtz, "Conférences Scientifiques de Bonn."—"Revue des Cours Scientifiques," 10th February, 1867, p. 78.

which it will give when set going again will only occupy the thousandth part of a second.* Now these two blows cause a determinate and appreciable sound. The sound, then, given in a second by the wheel when it has all its teeth, comprises a thousand similar successive sounds, each perceptible to consciousness. In other words, the whole sensation which lasts a second, is made up of a continuous series of a thousand similar sensations, each lasting one-thousandth part of a second, and each *perceptible to consciousness.* But as we have just seen, each one of them comprises in itself at least two successive elementary sensations, which, *if isolated, would not come within our consciousness,* and, to be perceptible, must be combined in pairs. Here we have the elements of a sensation lasting a second, and the elements of its elements.

Now, in the passage from the deep to the acute note, what become of these elementary sensations of which we are conscious? It is plain that each of them lasts less and less time and that its maximum sound becomes nearer and nearer to the maximum of the succeeding sound; hence it will necessarily become less and less distinct, and at last we shall cease to perceive any maximum or minimum in it; this is what happens; in proportion as the note becomes acute, the number and plurality still apparent, though indistinctly, in the low note, disappear and wholly vanish. Consciousness no longer distinguishes, even vaguely, the little composing sensations; the whole sound appears one and united.—At the same time, it puts on a new appearance, it seems thinner and more drawn out. This arises from the closer arrangement of the maxima, and from the shorter time occupied by the molecules of the sensation, which, though as numerous as before, are smaller. It follows that, as regards consciousness, our sensations of sound arrange themselves in a pyramid: at the base, are those of very deep sound, composed of longer elementary sensations and more distant maxima; at the summit, are those of very acute

* Mueller (tr. Baly), ii. 973 and 1298, Experiments of Savart.

sound, composed of shorter elementary sensations and of more closely ranged maxima; this is why we say of sounds that some are higher and some lower, and arrange them in a scale.—Hence we see that the qualities of deep or acute, of high or low, of full or drawn out, of vibrating or firm, by which we distinguish the different notes of the scale, depend on the degree of brevity of the elementary sensation, and the degree of proximity of its maxima. Here, already, we have reduced quality to quantity.

IV. It is also thus reducible in other respects.—First, as to intensity, the reduction is complete. The different degrees of force or intensity of any one sensation of sound are the different degrees by which it passes from its minimum to its maximum, and we know that these degrees have as their necessary and sufficient condition different degrees of condensation of the wave of air. Now, mathematics show us that in each elementary wave, there is a maximum and a minimum of condensation, which explains how it is we find in each elementary sensation a maximum and a minimum of intensity. Mathematics further show that in the two series of waves produced by two notes sounded in unison, the condensations combine and become of double strength; which explains how it is that in the sensations of sound so produced the intensities combine and become doubly as great. Consequently, when we are given the law connecting the elementary sensation with its condition, we are able to follow the elementary sensation under all its aspects and in all its degrees, far above the range of consciousness, by following mathematically the changes and degrees of its condition.

In the second place, an indirect analysis comes to our aid to explain with the most complete success that undefinable quality which seemed to resist all the efforts of direct analysis, tone.* If the same note is played by various instruments of different tone, it is not a simple sound but a combination of sounds, of which the principal

* Helmholtz, "Die Lehre von den Tonempfindungen."

one—the same for all the instruments—is the fundamental note; and the others, varying with particular instruments, are supplementary notes of less strength, termed superior harmonics, arising from vibrations twice, three, four, five, six, seven, eight, nine, or ten times as quick as those of the fundamental note. Thus, in the piano, we can hear without difficulty the six first harmonics of each note, but not the seventh or ninth. The violin, under the bow, gives the six first harmonics more feebly; but the higher ones, from the sixth to the tenth, are very distinct. The pipes of covered organs give a hollow sound, arising from the isolation of the odd harmonics. The clarionet gives a nasal sound, in which again there are only the odd harmonics; but of these, the higher ones predominate. Hence it follows that differences of tone arise from the addition of different harmonics to the fundamental note. By following out this principle, and with the aid of an instrument called a résonnateur, it has been proved that this same circumstance explains the different vowel-sounds of the human voice—that is to say, the variations which the same note presents, when pronounced in turn *u, a, e, i, o, eu, ou*. Analogous considerations show us how sounds become either harsh and rough, or smooth and even. So that these differences of sensation hitherto irreducible, and denoted by idle metaphors, are reduced to the intervention of little subsidiary and complementary sensations of the same kind, which, attaching themselves to the principal sensation, give it a special character and unique appearance, while consciousness, which sees the whole and nothing but the whole, is unable to distinguish these feeble auxiliaries, and therefore to recognise that, though inferior in strength to the principal sensation, they are, in nature, identical with it, and that, while entirely similar to one another, they differ only, according to the tone, in number and acuteness.

This being settled, we are in a position to explain sensations of noise, and their innumerable varieties. The science of acoustics shows us their general mode of formation, though without entering into the details of each particular

one. Like sensations of musical sounds, they are compound. But while the sensation of musical sound corresponds to a series of vibrations, equal in length and duration, that of noise corresponds to a series of vibrations, unequal in duration and length; and hence we conclude that in the first instance the elementary sensations are similar, and in the second dissimilar; and this explains the infinite number of sensations of noise and the impossibility of grouping them like those of musical sound in a single series; there are no limits to the combinations of dissimilar sounds; having no fixed relations between themselves, they can only produce a chaos.

We see now in what all the differences and peculiarities of sounds consist. Given two continuous elementary sensations, the one preceding and the other following, the two united form, as far as consciousness is concerned, a single whole sensation, which we term a sensation of sound.—If the two are similar, the sound is musical; if they are dissimilar, it is a noise.—If, in the couple so formed, the elements are of longer duration, the sound is deeper; if of shorter duration, the sound is more acute.—In every elementary sensation, there is a maximum; and according as the time between two maxima diminishes, the sound becomes more even.—If the maxima of one couple are greater than those of another, the whole sound of the first couple is more intense than the whole sound of the second.—If to the whole sound be added complementary sounds, less intense, and twice, three, four, or several times as acute, the tone varies with the variations of the complementaries.—If we conceive two given elements, on the one hand, the elementary sensation, on the other, the quantity we call time; we have in them the materials necessary to construct sensations of sound.—Two elementary sensations are discontinuous or continuous, that is to say, are separated by an appreciable or unappreciable portion of this quantity; and the sound is accordingly null or appreciable.—They occupy equal or unequal portions of this quantity; and the sound is accordingly musical or not musical.—

The portions so occupied are larger or smaller; and the sound accordingly becomes deeper or higher.—If we now conceive the magnitude or intensity of the elementary sensation itself; with this new element, the construction is accomplished.—The elementary sensation having a maximum of intensity, the maxima of two elementary sensations may be discontinuous or continuous, that is to say, separated by an appreciable portion of time or not; and the sensation is accordingly composed of appreciable portions, or uniform.—The maxima of two elementary sensations are greater or less than the maxima of two others; and the sound is accordingly more or less intense.—There are added to a sound different groups of sounds of less intensity, but of an acuteness the multiple of its own; and the sound has such-and-such a tone accordingly. So that all differences of sound, though apparently irreducible, are reduced to differences of magnitude introduced into the same elementary sensation, these differences being furnished sometimes by the magnitude or intensity of the sensation itself, sometimes by that particular magnitude we denominate time.

Let us now consider the elementary sensation itself. In the noise which precedes the musical note,* it is united with other elementary sensations of unequal duration, and forms with them a heterogeneous compound. In the musical note which is formed by accelerated and approximating noises, it is united with other elementary sensations, of duration equal to its own, and forms with them a homogeneous compound. But for it to reach our consciousness there must always be one or other of these combinations; it must be enlarged in order to be distinguished. When isolated, the inner sense does not perceive it; but it still exists, for in the very deep musical note we perceive it incessantly repeated and making up the note; and again, there can clearly be no compound without components.—On the other hand, we have seen that in the high as in the low note, the elementary sensation has a

* See the Wheel of Savart, and the Sirens.

maximum; we discover this maximum in the very low note, we do not discover it in the high note; still it exists in the one as in the other; but, in the very low note, the greater interval between the two maxima enables us to distinguish them, while, in the high note, their proximity prevents our doing so.—Further than this, every elementary sensation, in order to pass from its minimum to its maximum, passes in its short duration through an infinite number of degrees; much more therefore are these degrees insensible to consciousness; so that, in a high note, the indistinct elementary sensation comprehends not only two indistinct extreme states, but an infinite number of indistinct intermediate states.

We get a glance here at the obscure and infinite world extending beneath our distinct sensations. These are compounds and wholes. For their elements to be perceptible to consciousness, it is necessary for them to be added together, and so to acquire a certain bulk, and to occupy a certain time; if their group does not attain this bulk and does not last this time, we observe no change in our state. Nevertheless, though it escapes us, there is one; our internal sight has limits; outside these limits, internal events, though real, are for us as though they did not exist. They gain accessions, they undergo diminutions, they combine, they are decomposed, without our being conscious of it.* They may even, as we have just seen in the case of sensations of sound, have different degrees of composition, and consequently different degrees of recoil, beyond the grasp of consciousness. The elementary sensations directly making

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* Leibnitz, "Des Perceptions Insensibles," p. 65, "Nouveaux Essais sur l'Entendement," Ed. Jacques.

"To hear the sound of the sea, from the shore, we must necessarily hear the parts which make up the whole, that is to say, the noise of each wave, though each of these little noises only makes itself known to us in the confused assemblage of the whole, and would not be observed if the wave causing it were alone by itself. For we must be affected a little by the movement of this wave, and must have some perception of its sound, however slight; otherwise we should have none of the sound of a hundred thousand such, since a hundred thousand nothings cannot make up anything."—Cf. Hamilton, Lectures, &c., i. 349–351, cited Mervoyer, "De l'Association des Idées," p. 337.

up our ordinary sensations are themselves compounded of sensations of less intensity and duration, and so on. Thus, there is going on within us a subterranean process of infinite extent, its products alone are known to us, and are only known to us in the mass. As to elements and their elements, consciousness does not attain to them, reasoning concludes that they exist; they are to sensations what secondary molecules and primitive atoms are to bodies; we have but an abstract conception of them, and what represents them to us is not an image, but a notation.

CHAPTER II.

SENSATIONS OF SIGHT, OF SMELL, OF TASTE, OF TOUCH, AND THEIR ELEMENTS.

I. A SIMILAR, though somewhat less complete, reduction may be effected with sensations of sight.* We all know that a ray of white light may be divided with a prism into several rays of different colours. It spreads out into a spectrum, in which the colours form a continuous scale. At the commencement of the scale is red; then come orange and the different yellows, then green, the different blues, indigo, and lastly violet,† and each of these tints passes by intermediate stages into the one preceding it and the one following it.—Here are an infinite number of distinct sensations connected by intermediate stages. Let us examine their external conditions. The science of optics shows us that the spectrum is formed by the different rays which make up the white ray being inflected, some more and some less, in passing through the prism; this inflection increases with the shortness and rapidity of the waves; therefore, if we follow, from red to violet, the series of rays which form the spectrum, we find that the shortening and acceleration of the waves go on increasing. Thus, from red to violet, each sensation corresponds to waves quicker and shorter than those of the preceding sensation, slower and longer than those of the succeeding sensation. An increase of speed and diminution of length in the waves are sufficient to determine the variations which our sensation of colour undergoes in passing from red to violet.

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* Helmholtz, "Physiologische Optik," part ii.

† M. Helmholtz distinguishes the following successive colours: red, orange, golden yellow, pure yellow, greenish-yellow, pure green, bluish-green, blue of water, cyanic blue, indigo, violet and ultra-violet.

Having premised this, let us consider the red; as we go down the spectrum, the sensation of red diminishes; it passes from its maximum to its minimum. There is then an elementary sensation, which decreases in proportion as the waves become shorter and more rapid.—But there is more than one such; for if there were only one, we should find that as we passed towards violet, it would simply grow feebler with the shortening and acceleration of the waves, and the entire spectrum would only present degrees of intensity of red, while in fact, we find at what appears to be the minimum of red, a second distinct sensation arising, that of yellow. There are then, at least two elementary sensations of colour.—Are there but two? If there were only two, for instance, that of red and that of yellow, the red, having its maximum at the commencement of the spectrum, and the yellow having its maximum at the centre of yellow, the first decreasing with the time and length of the waves, the second decreasing whenever the time and length of the waves are less or greater than the degree of time and length corresponding to the centre of yellow, we should see, on passing down the spectrum below this centre, yellow become indefinitely feebler till the end of the spectrum, without undergoing any other change. This is not so; for at the lower minimum of yellow we find a new distinct sensation appear, that of green.—There are then, at least three elementary sensations, and on studying the composition of the spectrum we find it is sufficient to admit three, one analogous to that of red, another to that of violet, and the last to that of green.

All the three are excited by every ray of the spectrum; but each of the three is differently excited by the same ray.—The first is at its maximum at about the central point of red; in proportion as we descend towards the violet and the waves become shorter and more rapid, its intensity diminishes and approaches its minimum.—The second is at its maximum at about the centre of the violet; and as we go back towards the red, and its waves become longer and slower, its intensity diminishes and approaches

its minimum.—The third is at its maximum at about the central point of the green; in proportion as we return towards the red, or descend towards the violet, that is to say, as the waves become either longer and slower, or shorter and more rapid, its intensity diminishes and approaches a minimum.—So that, as we pass from red to violet through all the degrees of the spectrum, the three component sensations vary from degree to degree, but each one in a special manner, the first passing insensibly from maximum to minimum, the second from minimum to maximum, the third passing first from a minimum to its maximum, and then from its maximum to a minimum, which explains at the same time the insensible passage by which every compound sensation in the spectrum is connected with the succeeding one, and the diversities of the ten or twelve principal compound sensations.*

We can readily see the object of this disposition of our being. If a simple ray excited in us one sensation of colour only, it would have a maximum, a minimum, and intermediate stages, nothing more; and for want of being able to contrast it with another, we should not observe it;† we should have no notion of colour; the luminous waves, in increasing or decreasing in speed and length, would only render the sensation more intense or more feeble; objects would differ only in higher or fainter colour; they would resemble the various parts of a drawing in which all the

* Helmholtz, ih. 191. The substance of this explanation is due to Young. He supposes that every nervous fibre of the retina is made up of three elementary fibres, differently excitable by the same ray. As Helmholtz observes, we may suppose that every nervous fibre of the retina possesses three different kinds of activity, excitable by the same ray, and this is very probable.—But we may dispense with all suppositions by admitting, instead of three nervous fibres or three nervous activities, three elementary sensations. In the anatomical or physiological hypothesis, the assumed fact is uncertain; for it is not certain that there are three different fibres in every nerve, or that one fibre has three kinds of action. In the psychological explanation, the admitted fact is positive; for it is certain that the three sensations, red, green, and violet, exist.—I have therefore made the necessary changes in the explanation of Helmholtz. "This hypothesis of Young's," he says, "gives a complete view and extraordinarily clear and simple explanation of all the phenomena connected with the physiological science of colours."

† "Persons affected with achromatopsy can only distinguish degrees of light and dark, they see all objects as they are represented in photography."—Wecker, "Maladies des Yeux," ii. 432.

differences are those of white, grey, and black.—If, on the other hand, every simple ray excited two sensations of colour only, we should still have the notion of colour; we should still distinguish two principal colours, their maxima, minima, intermediates and compounds; but very many of our sensations of colour would be wanting, and their whole arrangement would be reversed.—This we observe in studying various cases of illness or congenital infirmity, and the theory reducing our elementary sensations of colour to the three sensations of red, violet, and green, receives here a most striking confirmation from experience.*—The sensation of red is wanting in some persons; in others, that of green; after taking santonine, the sensation of violet is lost for some hours. In all these cases, not only is a principal sensation missing, but many others are altered, and both losses and alterations are precisely those which, according to theory, would result from the absence of the elementary sensation.—Finally, we obtain a more delicate and definitive verification.† According to the theory, the red and violet of the spectrum are, even at the points at which they seem most intense, compound sensations; for, to the elementary sensation which is then at its maximum, are joined two others which are then at a minimum; the first then is mingled and weakened; it is neither absolutely pure nor of the greatest possible strength. It will, then, be purer and stronger if we can remove these causes of impurity and weakness. Now there is a case in which we are able to do this; that is, when we have blunted the sensibility of the eye to the other colours. In this case we ought to see a red or violet more intense than those of the spectrum; and this is what happens. In this instance, which is unique, we

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* Helmholtz, 294, 848, 293, and Wecker, ibid.—"The ingestion of santonine brings on a particular variety of Daltonism by making the retina insensible to violet rays. . . ." Some persons "have no perception of blue; this state always coincides with insensibility of the retina to red rays. Others while distinguishing white, grey, and black from all other colours, do not distinguish other colours from one another. In others, the retina is insensible to violet, while other colours are perceived, if strongly marked and in a bright light."

† Helmholtz, ib. 369, 370.

are able to isolate one of our elementary sensations of colour. By a lucky hit in psychological chemistry, we extract it from the ternary compound in which it is usually combined, and in which theory alone had detected it.

11. With the three elementary sensations of colour we are able to construct the rest. And first, if we represent by a curve the increase and decrease which each of them undergoes as it passes down the spectrum, we shall see the three different variations of their respective intensities produce the different colours of the spectrum.*—The longest and slowest waves, placed at the summit of the spectrum, excite the elementary sensation of red strongly, and the two others feebly; the result is the sensation of spectral red.—Lower down, at the point denoted by yellow, the waves, already not so long and slow, excite the elementary sensations of red and green with moderate intensity; and that of violet feebly; and then we have the sensation of spectral yellow.—Towards the middle of the spectrum, the waves, which then have a medium length and speed, excite the elementary sensation of green strongly, and the others much more feebly; our entire sensation is that of spectral green.—Lower down, when the waves begin to grow short and quick, the elementary sensations of violet and green are excited with moderate force, and that of red more feebly; then we see spectral blue.—Towards the lowest part, when the acceleration and shortening of the waves has further increased, the elementary sensation of violet is strong, and those of red and green are very weak; and the compound sensation we call violet is produced.

On the other hand, when the three elementary sensations are of about equal force and no one predominates over the others, we have the sensation of white, or of whitish colours. This happens in many cases; first, when all the rays of the spectrum, collected again by another prism, strike the retina at the same point, and thus produce the maximum, minimum, and all the degrees of each elementary sensa-

* Helmholtz, 291.

tion; again when, two rays being selected from the spectrum, the inequality of the three elementary sensations excited by the first is compensated by the inverse inequality of the three elementary sensations excited by the second. In this case, the two spectral colours produced by the two rays are said to be complementary to one another, and they form a distinct couple. Among such couples we reckon four principal ones, red and bluish-green, orange and cyanic blue, yellow and indigo, greenish-yellow and violet; combined in their respective pairs, these colours give us the sensation of white, and we find a fixed distance between such pairs on the spectrum.—If, on the contrary, we take the two colours at the furthest distance from one another on the spectrum, red and violet, their mixture produces a sensation of distinct colour, that of purple.—These two observations afford us the law governing all mixtures of spectral colours.—Two colours being given for mixture, their distance on the spectrum, compared with the fixed distance between complementary colours, differs from it by a greater or less quantity. The smaller this quantity is, the nearer to white or whitish will be the colour produced by the mixture; and on the contrary, the greater this quantity is, the freer from white, or more "saturated," will the colour formed by the mixture be.—On the other hand, this distance may exceed or be less than the fixed distance. The more it exceeds the fixed distance and the nearer it approaches to the extreme possible distance, the nearer will the colour formed by the mixture approximate to purple, which is produced when the separation is most complete; on the contrary, the further it is below the fixed distance and the smaller the separation becomes, the more does the colour produced approximate to the intermediate colour, in which the separation of the two component spectral colours disappears.* All these conclusions are confirmed by experience.

A last colour remains, black, which is not a sensation, but the absence of all sensation at a particular place and

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* Helmholtz, 279.

moment, when this place and moment are compared with others in which the sensation is present. But consciousness is so ill-acquainted with our internal events that she places in the same rank, as colours, our sensations and our wants of sensation; what strike her are differences between our states, and, on account of this, she sets together as similar facts the passage from repose to action, and that from action to repose, observing them as contrary, but without distinguishing that one is negative, the other positive. The different degrees of black or of want of sensation come in then to complicate the colours already constructed. "Prismatic analysis proves that grey becomes identical with white, brown with yellow, reddish brown with red, olive green with green, when the white, yellow, red, and green are feebly luminous."

These data being given, we have all the elements necessary to explain all sensations of colour, and we see the elements of the sensation form compounds, which combining together form more complex compounds, and so on, just as we see physical atoms form chemical molecules, these form chemical compounds, and these again, the ordinary minerals found in nature.—By our utmost analysis we arrive at three elementary colours, all simultaneously excited, though each one differently, by a simple ray of the prism. Their union forms a spectral colour.—Many spectral colours united form, in accordance with a fixed law, white, purple, and an infinite number of compound colours; and the addition of black, that is to say, the enfeebling the whole sensation, introduces an infinity of shades in all these products.—These products themselves form, by their combinations, the ordinary colours we observe in the world surrounding us.

Positive science stops here; experience does not enable us to mount higher than the three elementary sensations of colour. We are dealing with an instrument far more complicated than the sensation of hearing. In fact, for every undulation we have three sensations instead of one. With sound again, the vibrations sometimes succeed one another

slowly enough to enable us to distinguish the elementary sensation corresponding to each of them; there are only sixteen and a half per second in the *ut* of an organ-pipe thirty-two feet long; and so we are able to observe that our whole sensation is made up of successive small sensations having each a maximum and minimum; we distinguish almost precisely these component sensations. With sight, on the contrary, at the extremity of red, the part of the spectrum where the vibrations succeed most slowly,* there are 451 billions of them in a second; it is plain that, were we able to isolate the sensation of red from the two other elementary sensations, we could never distinguish from one another component sensations so prodigiously numerous and of so prodigiously short duration. All we can admit with confidence is that the elementary sensation of red, like that of the lowest note of *ut*, is composed of successive sensations. For Wheatstone's experiments show that such a light as that of the electric spark is enough to produce a sensation on the retina; that this light is, so to speak, instantaneous; that it lasts less than the millionth of a second; and that thus a sensation of light lasting a second is made up of at least a million successive sensations. The number of these cannot be determined; it is probably much greater; perhaps with the ethereal undulation, as with the undulation of air, two successive vibrations are sufficient to produce a sensation still perceptible to consciousness; if so, the shortest sensation of light perceptible to consciousness would—as is the case with the shortest sensation of hearing perceptible to consciousness—be compounded of two elementary sensations imperceptible to consciousness, and having each a maximum or minimum and intermediate stages.—Without pushing the induction to this extent, the case of the electric spark shows that the sensation of light, like that of a very acute sound, is composed of a continuous succession of very numerous, successive, and similar sensations, forming, as far

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* Mueller (tr. Baly), ii. 1109, and Helmholtz, p. 32.—451 billions for the slowest, 789 billions in the quickest.

as we are concerned, a simple undecomposable mass. A new proof of the unnoticed work going on in the depth of our being, beyond the range of our consciousness, and a new example of the latent, complex, and innumerable combinations, of which we only perceive the totals or the effects.

III. We must not expect to find such complete reductions in the cases of taste and smell. With air, or ether, we know the mode of action, which is, an undulation of calculable length and speed, and thus we are able to draw conclusions from it to the corresponding sensations. Besides, this mode of action is uniform, and the nerve, moreover, is specially constructed to receive it; we find proof of this in the designed structure of the organism of which the nerve forms part, and in the similitude of the sensations produced through the nerve by a blow or an electric current applied to the eye or ear. The nerve itself, then, is capable of uniform action; and so it is natural that sensations excited by its action should be readily referable to a simple type, as happens with those of sound, or to types few in number, as with those of colour. — With the other groups of sensations all this is reversed. We are ignorant of the mode of action of volatile substances on the olfactory nerves and of liquified substances on the gustatory nerves; it is recognised to be chemical, but here our knowledge stops; we do not know whether it is an undulation or what other movement; we have not the least idea of its elements, and are unable to avail ourselves of such an idea to form conclusions as to the corresponding sensations.—And yet, from the single fact that it is chemical, we may conclude something as to the composition of the sensations it excites in us through the medium of the nerve.

Before commencing this inquiry, we must distinguish sensations of smell and taste, strictly so called, from accompanying sensations. For, what we term a smell or taste is, in general, a very complex sensation; the olfactory or gustatory nerves only contribute a part of it; another very considerable part is referable to nerves of touch, similar to

those spread over the rest of the body, and from which we receive sensations of contact, of muscular contraction, heat, cold, local pains, and all their kinds.—To begin with smell.* Numbers of what are termed sensations of smell comprise other sensations. And first, sensations of pungent smell are divisible in two parts; they all comprise sensations of touch and, perhaps, are nothing more; such is the smell of ammonia, which is principally a stinging, as it is transmitted by other nerves than the special ones; the vapour of ammonia produces on the conjunctiva an effect precisely similar to its smell. This stinging may subsist even after the strict sensation of smell has been lost; some great snuff-takers become insensible to smells, pleasant or otherwise, but continue to take snuff, as they still feel the tingling it produces.—Appetizing and nauseating smells are also thus divisible. The strict sensation of smell is here combined with another, which, according to the state of the stomach, ceases, is augmented, or reversed; the same smell, that of a plate of hot meat, is agreeable when we are hungry, and disagreeable when we are suffering from indigestion; it is probable that, in this case, certain deep-seated nerves of the alimentary canal are called into action, and that the whole sensation is made up of a sensation of the olfactory nerves and several accompanying sensations.—Finally, we may also divide refreshing and suffocating smells, comprising, on the one hand, those of the volatile salts, of eau-de-Cologne, of tar, of tan; and, on the other hand, that of a close room, of a pastrycook's shop, of a cotton factory, of a cloth warehouse; here we plainly have, in addition to the strict sensation of smell, a sensation of comfort or uneasiness, arising from the air-passages, and conducted by the nerves of touch and pain.—I think, too, that in many cases, if, for instance, we inhale alcohol, a feeble sensation of heat comes in to complicate the strict sensation of smell.—Pure sensations of smell remain, agreeable or disagreeable in themselves; those, for instance, of the violet and of assafœtida; there are an infinite number of them,

* Bain, "Senses and Intellect," 173.

of which we can only say, that they are agreeable or disagreeable; in themselves, they resist all analysis, and in order to denote them we have to name the bodies producing them.

As to taste, what we generally term a flavour, comprises, besides the strict sensation of taste, a number of sensations of other kinds.—In the first place, as the back of the mouth and nose communicate, the olfactory nerve is in operation at the same time as the gustatory.* "If you close your eyes and nostrils, and have different kinds of sweetmeats, for instance, placed on your tongue, then aromatic creams, of vanille, of coffee, &c., in every case you will only perceive a sweet, sugared taste, and will not be able to distinguish the different substances employed." In the same way it can be proved that "the urinous taste we attribute to fixed alkaline bases, does not belong to these substances, but to the ammonia set free by the reaction of the fixed alkaline bases on the ammoniacal salts contained in the saliva." Here, again, a sensation of smell, or rather of nasal touch, is included in the sensation of taste.—Secondly, strict sensations of taste are frequently combined with a different sensation, sometimes agreeable and attractive, sometimes disagreeable and repulsive, belonging to other nerves of the alimentary canal. This accompanying sensation varies, while the others remain constant; the same good plate of meat is agreeable or disagreeable, accordingly as the stomach is empty or loaded. Besides this, it arises in other ways; it has no need, like the other, of chemical action as an excitant; mere contact is enough; a finger or a feather in the throat will produce a sensation of disgust.—Thirdly,† "Many impressions referred to taste are simply tactile;" such, for instance, are acrid, irritant, astringent flavours, which are sensations of touch, not of taste.—Fourthly, certain flavours are combined with sensations of heat and cold; the sensation of heat accompanying strong drinks is well known, and also the cool sensation we

* Longet, "Traité de Physiologie," ii. 171. Bain, "Senses and Intellect," 157.
† Vernier, cited by Longet, "Traité d'Anatomie et de Physiologie du Système Nerveux," ii. 170. Bain, ibid.

find as an element in the flavour of certain sweetmeats.—Lastly, different sensations are excited by the same body in different parts of the mouth, and not only different accompanying sensations, but different sensations of pure taste.* "Numbers of bodies, and particularly the salts, exhibit the remarkable peculiarity of exciting, when applied to the back of the tongue, an entirely different sensation from what they excite when applied to the anterior part. Thus, the solid acetate of potash, of a burning acidity in the anterior part of the mouth, becomes insipid, bitter, and nauseating at the back, and loses entirely its acid pungent taste. Hydrochlorate of potash, simply salt and fresh in the anterior part, becomes sweetish at the back. Nitrate of potash, fresh and pungent in front, is insipid and slightly bitter at the back. Alum is fresh, acid, and astringent when crushed in the front of the mouth, while behind it gives a sweetish taste without the least acidity. Sulphate of soda is distinctly salt in front, and distinctly bitter behind." Acetate of lead, fresh, piquant, and astringent in front, becomes sweet at the back.—Hence it follows that an ordinary sensation of taste may have several distinct elements in itself, in addition to the four kinds of elements furnished by accompanying sensations. For, in addition to the non-gustatory nerves, there are different gustatory nerves which intervene to produce it. The mouth, then, is not a simple organ, but a succession of organs, and a taste, even one strictly so called, may be a succession of tastes.

Let us simplify the matter; let us lay aside all that part of the sensation which may be referred to touch, such as acidity, astringency, irritation, heat, coolness, the spontaneous muscular sensation radiating towards the alimentary canal, and consider simply the sensations of the gustatory nerves themselves, and put them on the same footing, whether they arise in the anterior part, or at the back of the mouth; their principal types are the sensations of

* Longet, "Traité de Physiologie," ii. 167. "Experiments of Guyot and Admyrault."

bitter and sweet, with their innumerable varieties; when we have thus named them, we are at the end of our knowledge, as happened just now when we called sensations of smell fetid or perfumed.—Still, let us see what we can learn in either case by availing ourselves of previous reductions, and by studying the circumstances in which these sensations arise. They have, like the rest, as direct stimulus, an action of the nerve transmitted to the nervous centres. Now it is admitted, in accordance with all known facts, that two different sensations indicate two different states of the nervous centres, and, if the same nerve is concerned, two different actions of that nerve.—It remains, then, to be known in what way the olfactory or gustatory nerves act; and, to arrive at this, we must determine the external event in *immediate* sequence to which its action commences.

Nothing is easier than to know the antecedents of this event; but it is difficult to determine accurately the event itself. We see, at first sight and by ordinary experience, that such a body excites in us such a sensation of taste or smell, that another excites in us the sensation of red or blue; but neither one nor the other excite these sensations otherwise than through media; the science of optics was required to tell us that undulations of an ether of certain length and speed are the media of action of the second; and it would be necessary to have recourse to a science already constructed to determine the media of action of the first.—Let us inquire, however, into this last immediate event in direct sequence to which the olfactory or gustatory nerves begin to act. A body has no taste unless in solution; the taste is increased when it is moved about and pressed to the gustatory membrane;* this membrane, again, must not be dry, or rendered insensible by cold. Again, the gustatory nerves are probably protected by a colloid membrane, permeable, as are all such, to non-colloid substances, but nearly impermeable to colloid substances, which accounts for the taste of non-colloid substances, and the want of taste in

* Bain, "Senses and Intellect," 156, 168.

colloid ones. All these facts lead us to the conclusion that the dissolved molecules of the body which is tasted penetrate the tissues of the tongue, and come in contact with the nervous papillæ; and there, under the influence of the animal heat, form with the liquid secretions *a chemical combination* varying with the variations of these secretions.*—Similarly, a body has no smell, except in a gaseous state; and the pituitary membrane must not be dry; it is also proved that, to be odorous, a gas must combine with oxygen at the surface of the pituitary membrane. All these facts lead to one and the same conclusion, that the molecules of gas become absorbed in the moisture of the pituitary membrane in contact with the olfactory fibres, and there form a *chemical combination* with the oxygen of the air.—Thus the action of the olfactory nerve, like that of the gustatory nerves, appears to have a chemical combination as its immediate antecedent.

Now what is a chemical combination? Chemists reply that a homogeneous body is made up of molecules precisely similar to one another, and extraordinarily small; that each of them, if the body is not simple, is itself composed of several different atoms much smaller still, and so situated, with respect to each other, as to remain in equilibrium; that a chemical combination takes place when a molecule, receiving an atom of another kind, passes into another state of equilibrium; that the atoms then leave their respective positions to take up new ones; that these displacements of atoms, acting at extremely small distances, are themselves extremely small; that, as these atoms are wonderfully small, we must, to explain their active force, attribute to them, on displacement, velocities of enormous magnitude; and that, therefore, every distinct chemical combination is made up of a distinct system of prodigiously small and rapid displace-

* Longet, ii. 164.—"The most delicate kinds of food are tasteless, earthy or bitter when the stomach is out of order. . . . The brain and sensorial nerves remain as they were, but the tongue is covered with a mucous or bilious coating, and everything produces a dull nauseous impression." Mueller (tr. Baly), ii. 1323.—"After chewing the root of the sweet-flag, milk and coffee taste acid to me."

ments, of which we cannot yet indicate the elements or explain precisely the type.* Here we have the immediate antecedent of the action of each olfactory or gustatory fibre; and we cannot help observing how closely it resembles the immediate antecedent of the action of the optic nerve, but with this difference, that in the second case the type and elements of the antecedent are known. In fact, in the vibration of ether, the active particles are also of extraordinary minuteness; their displacements are also wonderfully small and rapid; they form, also, a number of distinct systems. Only we know that these systems are all made up of waves, and we can measure the speed and length of each wave; and thus we are able to define exactly the elementary displacement by whose repetition each system is formed, to show that, in different systems, the elementary displacements differ in respect of quantity only, to reduce them all to a single type, to denote the corresponding elementary action of the optic nerve and brain, and to conclude the existence of an elementary optical sensation, by whose prodigiously rapid and multiplied repetitions our total sensations of colour are made up.—Unfortunately, chemistry is not so far advanced as optics; it can only prove the existence of systems of displacements, while the other science defines and measures them; it must wait till, like its rival, it can represent these infinitely small events, of which it only knows the final effect.—But it is plain that in the two cases the problem and solution are of similar nature. In each, movements are dealt with, the minuteness, speed, and number of which are wholly disproportioned to the ordinary magnitudes we are capable of estimating in time and space. We may compare, then, the wave of ether to a system of atomic movements, and a succession of similar waves of ether to a succession of similar systems of atomic movements. Consequently, thanks to the first case, we can, to some extent, represent to ourselves the second.

* "Chemistry has as yet been constructed with reference to masses only; its construction with reference to velocities remains to be accomplished."—Saigey, "De l'Unité des Forces Physiques," p. 184.

A molecule comes in contact with an olfactory fibre or a gustatory papilla; a system of atomic movements takes place in the molecule, and a corresponding action follows in the fibre; a second similar molecule arrives at the same point; a second similar system of atomic movements takes place, and a second exactly similar corresponding action follows in the same fibre. The two similar nervous actions have aroused two similar cerebral actions and two similar elementary sensations. But the number of such sensations, actions, and systems of movements succeeding in a second is enormous, and the whole sensation of smell or taste, like the whole sensation of colour, is but the sum of all the successive elementary sensations, the series of which occupies a certain time.*

We can now form an idea of the four special senses. The distinctive character of their sensations is that each, even the simplest, of those we are conscious of is made up of a succession of very numerous elementary sensations of extremely small duration, whose rhythm corresponds to the special rhythm of an external event, to an undulation of air or ether; to a system of atomic movements, forming the external natural antecedent with regard to which the sense was constructed, and by the presence of which it ordinarily acts.—What constitutes a special nerve is its capacity to arouse such elementary sensations. Those excited by the acoustic nerve correspond to undulations of the air comprised between two limits. Those of the optic nerve correspond to undulations of ether also comprised between two limits. Those to which the gustatory and olfactory nerves give rise, correspond to molecular movements of determinate form.

Compare, for instance, the two sensations which the same undulations of the air excite through the nerves of

* Certain points of agreement show us the connexion of our sensations of smell and taste with the atomic constitution, and therefore with the change of atomic constitution of the molecules (Bain, 152, 165). Three atoms of oxygen with two atoms of a metal form a compound of sweet or sugary taste.—All organic alkalis are very bitter.—Almost all acids have an acid taste.—Almost all salts of iron have an inky taste, &c.—Substances with a perfumed smell are carburets of hydrogen.—Substances of fetid smell have, nearly all of them, arsenic or sulphur in their bases, &c.

touch and the nerves of hearing; that is to say, on the one hand a more or less pronounced quivering and tickling, and on the other hand a sound more or less intense and acute. The external antecedent is the same in the two cases; but the elementary sensations excited through the medium of the acoustic nerve correspond to the elements of the undulation of the air, and this is not the case with the elementary sensations excited by the medium of the nerves of touch. For, in fact, all details and variations of the undulation of the air are represented in the whole sensation of hearing, and are not represented in the whole sensation of touch. In the sensation of hearing, the greater or less speed of the waves is represented by the greater or less acuteness of the sound; the tone, by a supplementary group of more feeble sensations; each wave, by an elementary sensation; the depth of the wave, by the intensity of the sound; the degrees of condensation of each wave, by the degrees of intensity of the sound. With the sensation of touch, on the contrary, the representation is imperfect; all we experience is that the quivering becomes stronger, and degenerates into a tickling, when the undulation becomes quicker and the condensations of the waves become stronger.—And so again another external event, the undulation of an ether, represents itself to us in two ways, by the tactile sensation of heat or cold, and the visual sensation of colour and light. In the second case, all the degrees of speed and length which the wave of ether assumes are precisely represented, but only when their speed and length attain that of the limit of red, and do not exceed that of the limit of violet. On the contrary, the first translation represents, not only waves comprised between the limits of red and violet, but many other waves situated outside those limits; but none of the waves are specially represented, and the sensation of heat or cold does but roughly represent the difference of intensity separating two systems of successive undulations.

Thus the four special senses are four special languages, each appropriate to a different subject, each admirably adapted to express one order of facts, and that order alone.

Touch, on the other hand, is a general language applicable to all subjects, but not well fitted to express the shades of meaning in the different subjects. In general, a sense is a system of spontaneous writing and of automatic notation, resembling the instruments of measurement of which we avail ourselves in physics and chemistry. Sometimes these are delicate and special, as the multiplying calorimeter, or the instrument invented for the self-registration of the movements of the heart; sometimes they are less delicate and of general use, as the balance which only serves to denote the final augmentation or diminution of weight in an experiment. Sometimes the elementary sensation corresponds, feature for feature, with the element by whose repetition the external event is made up; in this case the elementary sensation copies, one by one, the variations of this element, with their order and magnitude; but, if we apply it to elements of another kind, it is of no effect, or confused, or extreme, and unfit to represent them. Sometimes the elementary sensation does not thus correspond, feature for feature, to the element whose repetition constitutes the external event, and does not copy the several variations of this element; but, in this case, the external event, whatever it be, excites a body of elementary sensations, the whole of which represent it as a whole, though unprecisely and in the rough.

IV. This is the character of touch, and we see that it differs from the other senses, and that its elementary sensations do not correspond to any elementary external event, and so cannot be referred to any known type. Here, then, we are confronted with a new difficulty. There is no special event here, as in former instances, to serve as a guide in discovering elementary sensations. We have to seek out a new path; before attempting it, let us see whether among the sensations of touch we cannot find some to which others may be reduced; we must clear the ground before attempting to cultivate it.

In studying cases of partial paralysis, physiologists have first distinguished two groups of primitive sensations, one comprising sensations of the muscles, and the other sensa-

tions of the skin, the first having as origin the excitement of the nervous extremities found in the muscles, the second having as origin the excitement of the nervous papillæ found in the derma. Each of these two groups may be missing, without the other being affected.

When the first is wanting, we see that all the sensations of muscular contraction and expansion are absent, with all their several degrees of painful effort, fatigue, and cramp, besides the various sensations of cold, heat, contact, pain, electric shock, produced by the application of stimuli to the muscles in their normal state.* "As soon as the patients take their eyes off their limbs, they have no more consciousness of their position, or even of their existence. When in bed, they lose them, as it were, and are obliged to look for them, not knowing where they are. Sometimes they try to stretch out or bend some limb already stretched out or bent. On moving, they are ignorant of the extent of their movement, and frequently do not know whether they have moved or not. If they intend to move, but are prevented, they are unaware of it, and think they have moved, from having willed to do so. Passive movements may be occasioned in them by means of an electric apparatus, without their suspecting it. Their limbs seem to them deprived of weight. If their hands are plunged in water, they know by the cutaneous impression that it is a liquid, but, on moving the hand about, they do not experience that soft resistance which gives the notion of the fluidity of water, and do not know whether their hand is moving in the air or in the water. If the muscles be pressed, pinched, or kneaded, no distinct sensation takes place. They do not perceive the passage of an intense electric shock. A sharp instrument may be stuck in their flesh without their perceiving it; that is, unless they discover it through the persisting sensibility of the skin." Therefore, though they have retained all their muscular vigour, and are besides insensible to fatigue, they walk with great difficulty in the dark,

* Axenfeld, "Des Névroses," 339.

or when they cease to watch their movements with their eyes; the sensations of sight must be constantly present to supply the place of the absent muscular sensations. If both sensations fail them, "they can hardly keep themselves upright without stumbling or running the risk of a fall; their movements are either too extensive or not extensive enough; they readily let things slip from between their fingers, or sometimes crush them by too forcible a contraction." No other sensation is missing; they may still feel all the cutaneous sensations of tickling, contact, passive pressure, of superficial heat and pain. In other words, such patients can no longer estimate the state of their muscles, but are still perfectly capable of estimating the state of their skin.

There are patients, on the other hand, unable to estimate the state of their skin, but who can still estimate the state of their muscles.*—A workman, mentioned by Landry, had his fingers and hands insensible to all impressions of contact, pain, and heat; but his muscular sensations were unaffected. If his eyes were closed, and a somewhat bulky object were placed in his hand, he was surprised at not being able to close it; he had a sensation of resistance, but nothing more; he could not say what the object was, what was its form, size, kind, if it was cold or hot, rough or smooth, or even if there was any object there at all. A weight of a kilogramme was tied to his fist with a string without telling him what it was, and he thought some one was pulling his arm.

Here, then, we have two groups of sensations and two groups of nerves as distinct as those of the arm and leg,†

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* Landry, "Traité des Paralysies," i. 195, 182, 199.

† Brown-Séquard, "Journal de Physiologie," vi. pp. 124—615. According to Brown-Séquard, "sensitive impressions of pain and touch are transmitted in a cross direction to the spinal marrow, that is to say, the transmission to the brain of impressions arising in one half the body acts in the lateral half of the spinal marrow on the opposite side. On the contrary, impressions of muscular sensation pass without crossing to the anterior part of the spinal marrow." Consequently "the conductors of muscular sensation differ fundamentally from the conductors of other sensitive impressions." And the author adds, "not only do these conductors not cross in their passage to the spinal marrow, but further,

and, we may add, as similar. For the nerves of the muscles, like those of the skin, may give rise to sensations of contact, of cold and heat, of pleasure and pain.* "Persons wounded by a swordthrust, or the cut of a bistoury, frequently feel, in addition to the pain of the wound, the chill of the blade and its presence in the depth of the tissues, and, with many paralyties, although the skin may be quite insensible to all kinds of stimulation, a pressure, a shock, the prick of a pin thrust into the soft parts, are felt as deep-seated impressions of contact, shock, and pain." Besides, these same nerves give us pain when electricity is passed through them, or when they are excited by a very strong muscular contraction; and when excited by the expansion consequent on fatigue and shampooing they give pleasure. In all these respects, their action is the same as that of the nerves of the skin, from which they only differ by terminating in the muscles, and being excited by the stretching out or shortening of the muscles. But here, there is no difference of action, the difference is in the excitant; in the strict muscular sensation there is nothing more than a sort of wrenching, similar to the other sensations, and capable, like them, of passing into pain if pushed too far.

Thus we arrive at distinguishing in the nerves of the muscles, as in those of the skin, three, and only three kinds of sensations: those of contact, those of heat and cold, those of pleasure and pain.—And further, we find all

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they spring from this organ principally if not entirely by the anterior spinal roots."

There are very strong proofs of this theory in observations made in cases of wounds and lateral alterations of the spinal marrow. We see patients lose on one side, the right for instance, the power of experiencing sensations of touch, of pain, of cold, of heat, of tickling, and preserve on this same side, not only the power of moving their limbs, but also that of directing them exactly, and estimating all the degrees of muscular contraction; the inverse is the case on the left side. (See particularly the cases cited, pp. 238, 582).—In accordance with this theory, the nerves and conductors of muscular sensations are not only distinct from the nerves and conductors of tactile sensations, but, more than this, their anatomical course is different, and we can discover this course in the spinal marrow.

* Landry, ib. 201.

three kinds more or less vaguely present wherever there are tactile nerves. "The internal surface of the walls of the abdomen feels clearly the motion of the intestines. . . . . After a cold injection, a very plain sensation of cold is felt passing in the direction of the ascending and transverse colon."* The pharynx, œsophagus, and even the stomach, feel with some degree of exactitude the passage, warmth, and presence of food. And, in general, let us review successively the innumerable internal sensations, agreeable, painful, or indifferent, of organic life, those constituting hunger, thirst, and repletion, those accompanying digestion, respiration, circulation, copulation, or speech, those produced by wine, medicines, and various substances introduced into the circulation, besides all the spontaneous sensations, tinglings, itchings, shiverings, all the various hardly definable pains which serve as symptoms of different illnesses, all the special and very delicate sensations of touch we meet with in the conjunctiva, the tongue, and the interior of the nostrils, all the general and blunted sensations of touch such as we find on the surface of the wound after a recent amputation: we shall see that they are sensations of contact, of cold or heat, of pleasure or pain, more or less obscure, more or less ill-defined, more or less spread about, the same in substance, but diversified by their situation, the order of their phases, and the degree of their intensity.† We shall find no other element in them,

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* Landry, ibid. Longet, "Traité de Physiologie," ii. 179.

† Numbers of sensations which seem to have a special type and to be *sui generis*, are composed of elementary sensations of contact. "If," says M. Landry, "we cover a polished surface with a thin layer of talc and get a person who is not aware of this to pass the tip of his finger over it, he will imagine he is touching a greasy or oily body. . . ."—Again, if we sprinkle some drops of water on a marble table, and then, with our eyes shut, place the tip of a finger alternately on the dry and the wet spots, we shall not be able to distinguish one from the other. There is no special sensation, then, of damp or stickiness, but *a compound sensation of touch.* "This sensation," says M. Gratiolet, "is developed when the skin detaches itself from something *sticking* to it, as, for example, a surface covered with diachylon. It is most clear and distinct at the moment the adhesion comes to an end, and the skin which had been drawn by the surface suddenly returns to its proper state. From this sensation, when it is strong, comes the idea of viscidity; when slight, that of humidity. The contrary notion of dryness is derived from an absolute want of adherence. This is so far the case that when

and, by this first reduction, we bring tactile sensations under three types, and three only.

These types are not only distinct, but separable; each of them, as far at least as sensations of the skin are concerned, may severally be lost, while the other two are retained.*—In some cases the sensation of pain only is lost. Patients still perceive the other cutaneous sensations, such as heat, contact, tickling, and can recognise the touch of a finger, the brushing of a quill, the contact of a pin; but if, in the same spot, we prick them with the pin, it occasions no pain. "I can feel," said one of them, "that you prick and pinch me, but you do not hurt me." This is carried so far that sometimes the application of a white-hot cauterizing iron gives no pain. A girl, suffering from hysteria, at the Hôpital Saint-Antoine, upset boiling water over her hands, and did not find it out till she saw large blisters rising.—In other cases, sensations of heat and cold are alone wanting. The patient then says:—"I feel the form and consistency of the body touching me, but cannot tell whether it is hot or cold."—Finally, in other cases, the sensation of touch only is wanting. Here, for instance, the patient does not feel small objects placed between the tips of his fingers; but "if pricked there, even superficially, it is plainly felt."—On the other hand, each type of sensation may subsist alone, the other two being lost. Some patients who no longer feel sensations of pain or heat, still feel contact at the same point. Others, more numerous, no longer feel sensations of pain and contact, but those of temperature

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the hand is plunged in water we do not feel this humidity, nor when it is plunged in oil do we feel its oiliness. In fact, bodies which an intermediate layer of water cause to *adhere* to us, no longer adhere when plunged in water, and so with bodies plunged in oil. . . . The skin is capable of receiving impressions on two layers—the one superficial, the other deep-seated. When the sensibility of the deep-seated layer is brought into play, the sensation of pressure arises."—Gratiolet, "Anatomie Comparée du Système Nerveux," ii. 409. Landry, "Paralysies," 159, 179.

* Beau, "Archives Générales de Médecine," Janvier, 1848.—Delacour, thèse, Janvier, 1850.—Landry, "Recherches sur les Sensations Tactiles."—"Traité des Paralysies."—Axenfeld, "Des Névroses," 332.

This separation has not been observed in the muscular sensations; when any of them disappear, the others disappear as well.

only. Others, finally, who can still feel pain, cannot feel heat or contact. It is plain that each of these three types of sensation has its special conditions, and when these conditions alone are abolished, or alone preserved, the isolated abolition or preservation of the type ensues.

Experience has discovered some among these conditions. If a limb is chilled up to a certain fixed point, it retains the sensation of contact, but ceases to experience that of pain: for instance, "if we apply to the knee a mixture of pounded ice and sea-salt, in the proportion of two parts of ice to one of salt, the skin becomes bloodless, and we may cauterize the limb without the patient feeling any other sensation than that of the pressure of the iron." Thus, the sensation of pain is subject to a special condition; to produce it, the circulation of the blood, and therefore the molecular wastings and repairs of the nerve, must go on with a certain degree of speed. With a less degree the nerve is no longer capable of the special type of action which arouses the sensation of pain, though it may still be capable of the special type of action which arouses the sensation of pressure and of contact.—We see that the sensation of pain requires for its production a condition, additional to those required by the sensation of contact; hence it follows that it may readily be abolished without inducing the abolition of the sensation of contact, and that the reverse is not the case; this is in conformity with experience. Persons who have lost all sensations of pain frequently retain sensations of contact; but very seldom do persons who have lost sensations of contact retain those of pain.*

This instance puts us in the track of the needed explanation. In fact, we have no need to suppose, with many physiologists, that there are three kinds of nerves intended to transmit impressions of contact, of heat and cold, and of pain respectively; each of the three classes being capable of being paralyzed singly, and of thus cutting away from us

* Axenfeld, ibid. 332. "The inverse case is rarely seen; when the sense of touch is lost, that of pain is lost at the same time, or, in other words, the existence of anæsthesia, strictly so called, *almost* invariably implies that of analgesia."

one kind of sensation without the other kinds being thereby abolished. The only thing which the facts attest is, that the three kinds of sensations have special conditions, and that these conditions may be singly destroyed.—What are these conditions? We may conceive many kinds.—They may be anatomical: this is the answer of the physiologists, of Landry, Brown-Séquard, and Luys. In fact, it is sufficient for the explanation of these isolated abolitions that there be three kinds of nerves; this solution is a manifest one, we are tempted to adopt it. But there are others, for the presence of a special nerve does not necessarily follow from the fact of a special condition.—There are two other possible explanations. First, the condition may be a special state of the same nerve, which would appear to be the case from the experiment in which the frozen knee becomes bloodless. Secondly, the condition may be a special state of the parts surrounding the nerve, and through which the external stimulus acts on the nerve; in this case, the same nerve, under the influence of the same external stimulus, would transmit different sensations, according as the parts between it and the stimulus were in different states. These last solutions are more abstract, but they agree better with the facts.

Weber's experiments appear to me conclusive as to this.*—If we dip into cold water a large nervous trunk, for instance, the cubital nerve, where it springs from between the two bones at the elbow, we find, in accordance with a well-known law, a sensation in the arm and two last fingers of the hand, occasioned by the nervous action going on at the elbow; now this sensation is not of cold, but simply of pain. Consequently, when we have a sensation of cold, it is not

* Article Tastsinn, 498, in "Handbuch der Physiologie," by Rudolf Wagner. Cf. Fick, "Anatomie und Physiologie der Sinnes Organe," 28, 30, 42, 43. From the anatomical structure of the organs of touch, he shows, by approximation and hypothesis, the different types of action which excite in the same nerve different sensations, that of heat or cold, that of pressure or contact. "It is probable that the stimulation of the nerves, in the sensation of heat or cold at the sensible periphery of the skin, is not immediately developed by a change of temperature of the nervous substance itself, but by the simultaneous changes supervening in the mechanical relations of the terminal corpuscles."

owing to the immediate action of cold on the nerve; for it was not felt just now, when the cold was acting immediately on the cubital nerve. In order to feel it, the cold must act indirectly; that is to say, through certain parts adjacent to the nerve, certain organs disposed for this purpose; these act directly on the nerve; the cold modifies them, and their modification impresses on the nerve a special type of action, which excites in us the special sensation of cold.—If, on the contrary, without paralyzing the nerve, we simply destroy in these adjacent parts the property they have of impressing this rhythm of action on the nerve, we shall cease to have the special sensation of cold; when the cold begins to act on the nerve, it will no longer excite the special sensation of cold, and will only excite, as we found just now in the case of the cubital nerve, the sensation of pain. This is what happens in certain illnesses. M. Axenfeld writes as to this—"With ataxic persons, whose cases are among those in which want of sensibility is most complete, I have often observed that cold was disagreeable without its being recognised as cold. When we question them as to the nature of their perception, all we can get from them is, 'It hurts me.'"—We are led to the same conclusion by studying the sensations of persons whose bodies present large cicatrices, consequent on amputations or other wounds. "The parts of the skin," says Weber, "in which the tactile organs have been destroyed, and are not completely reproduced, cannot distinguish heat and cold."—Similar experiments point out the presence of similar media in the case of the sensation of pressure. If the cubital nerve between the two bones of the elbow be pressed with the finger, the sensation in the fingers and forearm is not of pressure, but solely of dull pain. "Therefore," says Weber, "the sensation of pressure, and the power of distinguishing its numerous and different degrees, are only possible when the pressure acts on the organs of touch, and, through them, on the extremities of the tactile nerves; this sensation does not arise when the tactile nerves are directly compressed."—Consequently, the

sensation of pressure has for its special condition, not the pressure of the nerve, but a certain modification of certain organs or parts surrounding the nerve. If these organs be alone destroyed, or their capacity for undergoing this modification be alone suppressed, the sensation of pressure will alone be abolished.

Thus, in all cases, what is excited in us is a special type of action in the nerve, and what excites this special type of action in the nerve is a special modification of its appendages and dependent parts.—Consequently, to explain the three kinds of tactile sensations, and to comprehend how they may be singly abolished, there is no necessity of supposing them excited in us by distinct nerves of three different kinds: this is a gratuitous hypothesis which no vivisection or microscopic observation comes in to confirm. It is enough to admit that the same nerve or group of nerves is capable of many different types or rhythms of action, and that each of these rhythms is directly excited by the special modification which the external agents impress on the parts surrounding the nerve, whether on the tubes containing it, or on the blood washing it, or on some other of its internal accompaniments.

It is not impossible to form a notion of the differences of these rhythms. "Each tactile nervous fibre," says Fick, "can only transmit one and the same sensation which is capable only of degrees. . . . . But ordinary external stimuli do not arrive at these isolated elementary fibres; they come in contact with a group of fibres taken together. We may suppose that heat reaches these fibres *in a different order* from pressure."—"In fact, the nearer we draw to the true elementary sensation, the more does the difference between the sensation of heat and that of a mechanical stimulus seem to vanish. For instance, we can hardly distinguish a prick with a very fine needle from the touch of a spark of fire."—There is a further analogy; we know that the sensations of heat and cold, like those of pressure, become, when carried beyond a certain point, pure pain.—"Lastly, place on the skin some imperfectly conducting

body; for instance, a piece of paper, pierced with a hole of from 2 to 5 millimetres in diameter; through this hole apply to the skin, first, a mechanical stimulus, a pointed piece of wood, a pencil or a flock of wool; then, a heated stimulus, such as the radiation from a piece of hot metal." The two sensations, when thus limited to a minimum of nervous elements, are so similar that the subject of the experiment frequently mistakes the sensation of heat for one of contact, and that of contact for one of heat.—On the contrary, when the nervous elements are numerous, as when a large surface of the skin is subjected to the same experiments, there is not this confusion.—Plainly, then, here as before, the ordinary sensation is a whole; and, here as before, two whole sensations may be apparently irreducible to one another, though their elements may be the same; for this it is enough if the little composing sensations differ in number, magnitude, order and duration; their wholes form masses indivisible by consciousness, and seem simple facts, differing in essence and opposed in quality.

It is very probable that the sensation of pain is no more than a maximum; for all the others, pressure, tickling, cold, heat, change into pain when carried beyond a certain limit. —It is very probable that the sensation of pressure only differs from contact because in pressure "the terminal corpuscles of the deep-seated system are also engaged, while in contact they are not so."*—The sensation of tickling is most probably nothing more than a high degree of the sensation of touch; for, writes M. Axenfeld, "I have always found it disappear with the sensation of touch." And, in fact, the contact producing it, though apparently feeble, is actually excessive; the feather of the quill, or the piece of string which, when drawn slowly along the cheek or across the nose, grazes imperceptibly the extremity of a nervous papilla, evidently excites considerable activity in the terminal molecule of the papilla, for the sensation is a most

* See Fick and Gratiolet at the places mentioned. Cicatrices have no sensation of heat, and only a dull sensation of pain, but they retain the sensation of pressure. This arises from the terminal epithelial corpuscles being lost, while the deep-seated corpuscles of Pacini are still there.

vivid one and lasts for some seconds after the touch. The alteration of equilibrium in the nerve indicated by it is greater and slower in disappearing than when a pressure drives back uniformly a whole group of papillæ; if the whole displacement of flesh is then much greater, the relative displacement of the nervous molecules is much less. This is why the final sensation, if of less extent, is far more vivid.

To sum up; all that observation shows us in the nerves of touch, are different systems of transmissible molecular displacements. Composed of similar elements, they constitute dissimilar types or rhythms; undefinable by us in the present state of science, they are, like all displacements, definable in themselves, by the speed, magnitude, and order of their elements; and we may admit that, according to the order of their elements, they arouse in us sensations, sometimes of temperature, sometimes of contact or pressure; that at their minimum of speed and magnitude, they arouse feeble sensations of pressure, contact, and temperature; at their maximum of speed and magnitude, they excite in us the sensation of pain.

V. Let us attempt to cast a general glance over all these facts. A sensation of which we are conscious is a compound of more simple sensations, which are themselves composed of others still simpler, and so on. Thus the sensation produced by a harmony of thirds, *ut mi*, is made up of two *simultaneous* sensations of sound, *ut* and *mi*. Again, the sensation of *ut*, like that of *mi*, is made up of a comparatively strong sensation, that of *ut*, with the addition of other comparatively feeble simultaneous sensations, those of the superior harmonics. As to this comparatively strong sensation and these comparatively weak ones, each is made up of shorter *successive* sensations, which, when isolated, are still perceptible by consciousness, and whose number is equal to that of the vibrations of the air divided by two. Each of these little sensations is, in its turn, composed of two *successive* elementary sensations, which, taken singly, are not perceptible to consciousness. Finally, each of these elementary sensations is itself an infinite series of *successive*

sensations, equally imperceptible to consciousness, infinitely short, and increasing from a minimum to a maximum through an infinite number of intermediate stages. The whole results in the sensation of the chord *ut mi*, a compound of the fifth degree, just as a product in organic chemistry.—So, again, the sensation of white is composed in the first place of as many partial and *simultaneous* sensations of white as there are nervous fibres excited in the retina. Secondly, every partial sensation of white is constituted by *simultaneous* sensations of two, or more than two, complementary colours, for instance, yellow and indigo. Thirdly, the sensation of yellow, like that of indigo, is made up of three elementary and *simultaneous* sensations of colour, red, violet, and green, each having a particular degree of intensity. Fourthly, each of these three elementary sensations is composed of *successive* and continuous sensations of the same colour, sensations still perceptible to consciousness, and so numerous that there are at least a million of them in a second. Fifthly, each of these successive sensations, so prodigiously short, is, according to all analogies, composed, like those of sound, of still shorter *successive* sensations, imperceptible to consciousness, like the primitive sensations of sound. Finally, if we follow out our analogies to the end, we are led to conceive the sensation excited by each elementary wave of ether on the model of the sensation excited by each elementary wave of air, that is to say, as an infinite series of *successive* sensations infinitely short and increasing from a minimum to a maximum through an infinite number of degrees. Such is the sensation of white, a compound of the fifth or sixth degree.

This analysis brings three important principles to light. —The first is that two successive sensations which, singly, are insensible to consciousness, may, when combined, form a total sensation which consciousness perceives.—The second is that a sensation indecomposable by consciousness, and apparently simple, is a compound of successive simultaneous sensations which are themselves highly complex.—The third is that two sensations of the same kind and

differing only in the magnitude, order, and number of their elements, appear to consciousness as irreducible to one another, and as possessed of special qualities absolutely different.—Armed with these three principles, we can conceive the nature and diversity of the sensations of the other senses. In accordance with the second and third, smells, which like the colour white, appear simple sensations, are, like white, compound sensations, and the different smells, which like different tones, seem irreducible to one another, are, like these different tones, wholes, which, composed of the same elements, differ only in the magnitude, order, and number of those elements. We may form the same conclusion with respect to tastes, and the sensations of touch.—But here a difference appears. With smells and tastes an advance may be made which cannot be made with sensations of touch. An idea may be formed of the elementary sensations of which sensations of smell and taste are constituted, but not of those of which tactile sensations are constituted. We prove that the special and immediate antecedent which sets the olfactory nerves and gustatory nerves in action is a system of molecular displacements; we conceive this system of displacements to be represented in the nerves by a corresponding system of nervous actions, and to represent itself to us by a corresponding system of elementary sensations of taste and smell; we define, to a certain extent, these unknown elementary sensations by saying that they correspond to molecular movements of chemical action, as the known elementary sensations of hearing or sight correspond to waves of the undulations of air or ether.—There is nothing similar in the case of touch; we have no means of determining or conjecturing the rhythm of action impressed on the tactile nerves and transmitted by them to the nervous centres. The elementary nervous action, and consequently the elementary tactile sensation, remain beyond our grasp. All we know is that there is such an action, and therefore such a sensation; for whatever be the stimulus, the tactile nerve and the centres it is connected with always act

alike and in a way peculiar to them: their rhythm of action is special and unalterable; this is proved by the rhythm invariably exciting in us the same kind of sensation, and from this kind of sensation being excited by it alone.

Here are great gaps; they will only be filled when physiology is sufficiently advanced to determine the form and speed of the molecular movement, whose repetition constitutes nervous action. Meanwhile the theory of sensation is like a building in part completed, and in part planned out. —Still this incomplete construction is sufficient to give us an idea of the whole. We see that the innumerable sensations which we refer to one sense may be reduced in each case to an elementary sensation whose different groupings make up the different sensations of that sense. We conceive, in accordance with the three principles laid down, that the elementary sensations of the five senses may themselves be wholes, composed of the same elements, without other difference than that of the number, order, and magnitude of these elements, and therefore, like the distinct sensations of hearing or sight, they may be reduced to a single type. If so, there would be but one elementary sensation capable of various rhythms, as there is but one nervous texture capable of various types.*—And in fact, whatever may be the structure of the nerves and nervous centres whose action excites a sensation, however various this structure may be supposed, that which is transmitted from one end of the nerve to the other up to the ultimate nervous centre, is never more than a molecular displace-

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* Fick, "Lehrbuch der Anatomie und Physiologie der Sinnesorgane," 5. Der Erregungsvorgang, welche Form er auch immer haben mag, ist in allen nervösen Elementen gleicher Art, also ins besondere, in allen Nervenfasern, derselbe, sei dieser Faser im Hirn, im Rückenmark, oder in einem peripherischen Nervenstamm. . . . Indessen ist doch sehr warhscheinlich, dass der Erregungsvorgang in deu nervösen Elementen in gewissen Drehungen oder Umgruppirungen electromotorischen molecüle besteht.

See also Dr. Onimus, "De la Vibration Nerveuse et de l'action reflexe dans les Phénomènes Intellectuels."

Many physiologists admit that this displacement of the nervous molecules may be compared to a vibration or to the swing of a pendulum. At all events, there is an order of positions, which is altered, and then re-established.

ment, more or less rapid, extensive, and complex. A particle had a certain situation with respect to others; this situation changes, that is all; at the limit of all the sciences relating to bodies we invariably find mechanics. So that the different nervous actions which excite different sensations, can only be conceived as systems of movements. Thus all these actions, though differing in quantity, are the same in quality.—Now since, by the known correspondence between the sensation and the nervous action, sensations different in quantity are the same in quality, we arrive, by deduction, at the result foreshadowed by analogy.—At the foundation of all bodily events we find an infinitesimal event, imperceptible to the senses, movement, whose degrees and complications constitute the rest, whether the phenomena be physical, chemical, or physiological. At the foundation of all moral events, we guess the presence of an infinitesimal event, imperceptible to consciousness, whose degrees and complications make up all the rest, sensations, images, and ideas. What is this second event, and can we reduce one of these events to the other?

Meanwhile we have reached the foundations of human knowledge, and are capable of estimating their solidity.—We have seen that our senses are idioms, of which four are special and the last general. A sensation is a mental representative, the internal sign of the external fact exciting it. The special sensations of sight, hearing, smell, and taste are delicate and limited representatives, each of which severally translates accurately, by its characteristics, a special order of external facts. The general sensations of touch are coarse universal representatives translating, by their characteristics, nearly all the orders of external facts. Thus, every normal sensation corresponds to some external fact which it transcribes with greater or less approximation, and whose internal *substitute* it is. By this correspondence, internal events agree with external, and sensations, which are the elements of our ideas, find themselves naturally and beforehand adjusted to things, which adjustment will, further on, enable our ideas to be in conformity with things, and

consequently true.—On the other hand, we have seen that images are *substitutes* for sensations, past, future, or possible, that individual names are *substitutes* for images and sensations momentarily absent, that the more simple general names are *substitutes* for images and impossible sensations, that the more complex general names are *substitutes* for other names, and so on.—It seems then that nature has undertaken to provide in us representatives of her events, and has effected her purpose in the most economical way. She has provided, first, the sensation which translates the fact with more or less precision and delicacy; then, the surviving sensation capable of indefinite revival, that is to say, the image, which repeats the sensation, and consequently translates the fact itself; then, the name, a sensation or image of a particular kind, which, by virtue of its acquired properties, represents the general character of many similar facts, and replaces the impossible images and sensations which would be necessary to translate this isolated character. By means of this correspondence, of this repetition, and this replacement, external facts, present, past, future, special, general, simple, or complex, have their internal representatives, and this mental representative is always the same internal event, more or less compounded, repeated, and disguised.

BOOK IV.

OF THE PHYSICAL CONDITIONS OF MENTAL EVENTS.

CHAPTER I.

OF THE FUNCTIONS OF THE NERVOUS CENTRES.

I. We must stop here and change our route; we have come to the end of psychological analysis; let us see how far physiological analysis will carry us.

We have explored, as geologists, a great country, from its highest peaks to its seaboard, and, through all the accidents of surface, have recognised one and the same stratum supporting all the different varieties of soil. From our most abstract ideas to our crudest sensations, we have constantly found the same fundamental layer; ideas are sensations or images of a certain kind; images themselves are sensations capable of spontaneous revival. At the foundation of all these, we invariably find the sensation. But, when we come to the sensation, we are at the limits of the mental world; between it and the physical world there is a gulf, and, as it were, a deep sea; we can no longer make our accustomed borings; the water prevents us from examining whether the layer we have traced from end to end of the land goes on beneath it to rejoin the other continent. In five places, on the territory of the five senses, we have attempted to step over the ordinary bounds; with respect to the sensations of sight and hearing, we have pushed on to a considerable distance; with those of taste and smell, some advance has been made; and we see that, later on, a similar one may be accomplished with sensations of touch.—From all these indications, we have concluded that the sensations of each

sense, and probably those of the different senses, though apparently differing in quality, differ in quantity only, that the same elementary sensations may, by their differences of number, intensity, and proximity, make up whole sensations which consciousness pronounces irreducible to one another, and which therefore, different as they may apparently be, probably comprise one and the same fact, a kind of primitive rock whose different aspects are owing to the different depths of the water covering it. We have further proved that this rock, though invisible at a certain depth of water, still subsists there and is indefinitely prolonged, since at a certain degree of brevity or weakness, the sensation, though imperceptible to consciousness, is nevertheless real, and is found to be made up of infinitesimal elements. Beyond, then, the pyschological world observable by consciousness, there extends to infinity a pyschological world to which consciousness does not attain. Here then we part from consciousness, which can teach us nothing further, and pass to the other continent, to see if anatomy and physiology will not, on their side, indicate to us some projecting rock, connecting itself with ours, beneath the obscure sea which appears for ever to separate the two countries.

II. Let us look then for the physical facts on which our mental events depend, and first, for the conditions of sensation. These are direct or indirect, and make up a chain whose earlier links act only when the last one is affected.

Let us trace this chain. In the first place, there is the physical external event, the undulation of air or ether, the chemical action of the liquid or volatile body, the mechanical pressure, the change of temperature, which by dilatation or contraction of the parts arrives at affecting the nerve. This condition is plainly but an accessory and distant one. Though the nerve be so constructed as to translate more specially external movements of a certain type, it has its own type of action; it is a spring which, however it be set going, works in one way.*—The optic

* Mueller, "Physiology" (tr. Baly,) ii. 1069.

nerve when excited gives no other sensations than those of light; its various stimuli result in the same effect. An undulation of ether strikes it, and we have sensations of colour. It is excited by compressing the eyeball, and we see brilliant circles, which are termed *phosphènes*. It is divided in a surgical operation, and at the moment of its section, the patient sees sudden large bodies of light. An electric current is applied to it, and we see vivid flashes of light. Digitalis is absorbed into the blood, and the blood so altered excites in it sensations of flickering light.—So again the acoustic nerve gives no other sensations than those of sound,* whatever be the external event which sets it in operation, whether an undulation of air, electricity, irritation of the blood, or a narcotic absorbed into the blood.—So it is with the other senses, and notably with that of touch. The tactile nerves serve better than any others to prove this; for they are excited by a number of different external events, mechanical contact or pressure, the chemical action of caustics, of the air, and blood, change of temperature, undulations of air or ether, section with the bistoury; their action invariably results in a sensation of contact, or pressure, of temperature, or of pure pain.

Not only has each kind of nerve its special action, but the action of each kind is different. The external event may be the same, but, if it sets in motion nerves of different kinds, the sensations excited will be different. The same electric action arouses, according to the nerve it sets in action, here a sensation of light, there of sound, elsewhere again one of shock or of pricking. The same violent blow arouses a sensation of pressure and pain through the tactile nerves, of light through the medium of the optic nerve, of sound through the medium of the acoustic nerve. The same narcotic, introduced into the blood, arouses flashings when acting on the optic nerve, ringings when acting on the

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* That is, in the Limacean branch. See Flourens's experiments. On the other hand, it is sensible to pain in the vestibular branch; this then belongs to the group of tactile nerves.

acoustic nerve, formication when acting on the tactile nerves. —Thus each distinct kind of nerve has its individual and distinct mode of action.

Hence it follows that all external excitants may be absent; if the nerve enters into action of itself, we should have the same sensation in their absence as in their presence. —And, in fact, this is what happens: we experience without their concurrence a number of sensations which we term subjective or consecutive. They are especially numerous in the case of sight; the excitation of the optic nerve, and the consequent sensation of colours or of light, lasts after the undulation of ether has ceased to impress the retina; in such a case we continue to see, with closed eyelids, or with the eye turned in a different direction, the object we were first looking at; according to the circumstances, the object is uncoloured or coloured, of persistent or of changing colour; and these illusions are subject to known laws by which a multitude of singular facts are explicable.*—The same kinds of spontaneous sensations are found in the sense of hearing. "Such are the ringings and buzzings in the ears heard by persons of delicate nerves and patients with disease of the auditory nerve; such, too, is the noise heard in the ears for some time after a long journey in a noisy vehicle."† Subjective sensations of taste and smell are not so easy to detect. If some patients are continually complaining of smelling fetid odours, it is not certain that the origin of their sensation is in the nerve itself; it may possibly be found in the nervous centres.—But there is nothing more common than spontaneous action of the nerves of touch; it is enough to mention neuralgia, strictly so called; the simple action of the nerve, in the absence of all appreciable excitants, arouses, maintains, and then revives the keenest and most various sensations of pain.

This is why, if the state of the nerve changes, though

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* Helmholtz, "Handbuch der Physiologischen Optik." 2me partie, § 22–25.
† Mueller (tr. Baly), ii. 1072, 1210, 1310.

the excitant continue the same, the sensation changes in degree, or even in quality. For instance, if the nerve has become unduly exeitable, the least stimulus developes an extreme action, and the sensation is of terrible intensity: this is the case with the unfortunate patients who suffer from hyperæsthesia of the optic, acoustic, or tactile nerves. If, on the other hand, the nerve has become less excitable, or has ceased to be excitable at all, the strongest stimuli will only arouse in it weak or imperceptible sensations; this happens when the nerve is divided, tied, benumbed with cold, or paralysed by illness. Finally, if the nerve has become exeitable in a different way, its action, though induced by the same stimulus, is different, and the sensation is no longer the same; in indigestion or fever, all kinds of food have an earthy or bitter taste.—In short, the direct condition of the sensation is the action or molecular motion of the nerve; neither external events nor the other internal events of the living body matter much; they only act by means of the movement they excite; in themselves, they do nothing; they may be dispensed with. If the action of the nerve were always spontaneous, as it sometimes is; if this action were still produced according to the ordinary order and degree, the external world, and all within us excepting the nervous system, might be annihilated; we should still have the same sensations, and consequently the same images and the same ideas. Let us look, then, more closely into this nervous action, since there is no sensation without it, and since it is sufficient of itself to excite sensation.

III. When a sensitive nerve commences to act, a molecular movement is propagated through its whole course till it reaches the nervous centres.* The nerve is a conductor, just as the air which transmits the oscillations of a vibrating string, or the iron wire which transmits electric action. Two experiments prove this.—If it is compressed,

* This movement is produced in the central filament of the nerve, termed the axis-cylinder. It is the only essential part of the nerve. Vulpian, "Leçons sur la Physiologie du Système Nerveux," p. 55.

tied, or cut at any point between the nervous centres and the spot excited, there is no longer any sensation; in this case the nervous centres are intact, the terminal extremity of the nerve acts as before; the central part of the nerve, then, is what has ceased to act; therefore, it was previously acting; therefore when, in consequence of a terminal excitation, a sensation is produced, the nerve has acted in all its segments and through all its course.—On the other hand, in all parts of its course, this action results in the same effect.* At whatever point it may be irritated, the final sensation is the same. This extends so far that sometimes our associated images localize the sensation in parts which are insensible or absent. "There are kinds of paralysis in which the limbs are absolutely insensible to external irritations, though the severest pains are felt there." The fact is, the nerves which supply these limbs, though insensible at their extremities, are still irritable and irritated in the higher parts of their course. For the same reason, any section, compression, or irritation of a nervous trunk excites a sensation which appears to be situated in the parts to which the branches and terminal fibres of the trunk lead. If the arm be compressed with a tourniquet till it is insensible to excitations from without, and if the nervous trunk between the two bones of the elbow be then pressed, a keen sensation will be felt similar to that of an electric shock, and this sensation appears to be situated in the part whose nerves are benumbed. Every one has heard of the illusions of persons who have lost limbs. "These illusions persist and retain the same intensity through the whole of life; we may convince ourselves of this by questioning persons who have suffered an amputation a long time after they have undergone the operation. They are most vivid at the time of the inflammation of the stump and nervous trunks; the patients then complain of very severe pains throughout the limb which they have lost. After the cure there frequently remains for life

* Mueller, "Physiology" (tr. Baly), i. 686. Of the laws of action of sensitive nerves.

a feeling of formication, or even of pain, seated apparently in the non-existent external parts. These sensations are not vague, for the patient feels pains or pricking in some particular spot, the heel, the sole, or the back of the foot, the skin, &c. They end by becoming accustomed to it, and finally cease to perceive it; still, if attention be called to it, the sensation reappears, and is often felt very distinctly in the heel, the fingers, the sole of the foot, the hand," &c. In many cases, after seven, twelve, or even twenty years, the sensation is as plain as on the first day.—We see that for the purpose of exciting the sensation, the action of nerve is itself accessory only; it is only a medium; if the molecular movement which is propagated along its course is effective, it is simply because it excites another molecular movement in the nervous centres; just as the electric action that runs along the telegraph wire has no importance till it arrives at its destination and moves the needle of the dial-plate.

What is this molecular movement which is propagated throughout the conducting nerve? We cannot tell; all we know are some of its characteristics.* We prove that in the sensitive nerves, though its usual course is in the direction of the centres, it may also be directed towards the extremities. If we engraft the end of a rat's tail into the skin of its back, and then, when the grafting process is completed, cut the basilary portion of the tail about a centimetre from the root; after some months, if the grafted tail be pinched, the animal feels it, and turns round to bite; the irritation of the nerve, which, before the operation, acted in a centripetal direction, now acts in a centrifugal one.—We can further prove that the molecular movement is the same in a motor nerve and in a nerve of sensation. For if we unite end to end the fibres of a motor nerve, as the hypoglossal, with those of a sensitive nerve, like the lingual, on the one hand, the irritation of the sensitive nerve is visibly

* Vulpian, op. cit. 102, Experiments of Helmholtz, ib. 283; of Bert, ib. 287; of Philipeaux and Vulpian, ib. 290.

propagated along the motor nerve, and produces muscular contractions; while, on the other hand, it is very probable that the irritation of the motor nerve is propagated along the sensitive nerve, and excites pain.—We finally establish that "every excitation applied to any part of the length of a nervous fibre is immediately and simultaneously transmitted in two directions, centripetal and centrifugal," and we have some indications as to the velocity of this transmission.*—The conclusion from all this is, that "the intimate phenomena caused by an excitation of the nervous fibres are certainly identical, whether those fibres are motor, sensitive, or sympathetic." If the final effect be different, it arises from the different ramifications of the nervous fibres, some being in connexion with muscles, and others, with particular parts of the nervous centres; just as similar wires, which are the theatre of similar electrical phenomena, produce, according to the apparatus they are connected with, sometimes the ring of a bell, sometimes the displacement of a needle, sometimes the impact of a handle.

Hence it follows that the immediate condition of the sensation is found in the nervous centres; where there is produced a molecular movement of unknown nature, without which the sensation cannot arise, and which is of itself sufficient to give rise to it. And this, in fact, is what happens in very many cases. Many sensations arise in us without the intervention of the nerves, and by the simple excitation of the nervous centres. Such are hallucinations, strictly so called, of which we have seen numerous examples,† and, in which cases, we can, on most occasions, neither prove nor conjecture the existence of any irritation of the extremity or any portion of the course of the nerve.—I have described the visions which precede sleep, and which any one may observe in himself; in such a case, we close our eyes, we discard all excitation from without, we pacify all the nerves, and, as

* According to the most recent experiments, it is twenty-nine metres a second in the nerves of the human body. It varies with the surrounding temperature, and is not uniform throughout the length of the nerve.

† Book ii. chap. i.

might be expected, in the universal stillness of all the conductors which usually set the brain in action, our vague and feeble images become intense and clear; they are turned into sensations; we dream, we see absent objects. Excepting in the absence of objects and the inaction of the nerves, our state is the same then as in the cases of ordinary sensation; the brain is then acting as in the case of ordinary sensation; and it alone is acting, owing to the absence of objects and the inactivity of the nerves.—When it is excited directly and alone, hallucinations are produced, that is to say, spontaneous sensations with their associated images; and this is what happens when the brain is inflamed, or irritated by hashish.—Besides, medical observers have recorded many instances of patients some of whose nerves have been more or less completely destroyed, though the hallucinations corresponding to these nerves have been perfect.* Esquirol mentions among other cases that of "a Jewess, thirty-eight years old, blind and insane, who nevertheless saw the most extraordinary objects. She died suddenly; I found the optic nerves atrophied from their point of intersection to the points where they enter the eyeballs; in this case the transmission of impressions was clearly impossible."—"Two persons had each of them lost an eye by phthisis of the eyeball, and in their cases hallucinations were produced as readily on the side on which the eye was lost as on that of the sound eye."—"We have at present in the Salpêtrière," says Esquirol, "two women who are absolutely deaf, and who have no other delusion than that of hearing the voices of different persons, with whom they dispute night and day."—Strictly it might be objected that in these instances the central and as yet intact portion of the nerve is the starting-point of the irritation; but this is not probable; the hallucination is too systematic; if it proceeded from the nerve, it would be requisite that its different fibres should enter into action in the complex order and with the exact

* See Griesinger, "Traité des Maladies Mentales," 101–2, for numerous examples.

degree which an external excitant could alone impose on them. "A direct irritation," says Griesinger, "may certainly occasion luminous patches, globes of flame, and coloured figures in the retina, but not complex forms, such as houses, men, trees; it may determine buzzings and noises, loud or otherwise, in the ear, but not actual words or tunes." —The distinction is still more clearly marked in the hallucinations following the use of the microscope; the details of which I give from a letter written me by one of our most distinguished micrographists, M. Robin. "I have remarked," says he, "that after having looked through a microscope for some time, and especially when I have been aided by a strong light, the figures of the objects observed persist when I close my eyes.—They still persist whether I direct my eyes on the mahogany table holding my instruments, or on my drawing-board, which is of a greyish blue, or on my drawing paper.—They persist for about two or three minutes, oscillating about in a narrow circle; after diminishing in size and then disappearing they reappear, though paler; after two or three reappearances, more and more faint, they cease to reappear.—They disappear more readily when I rest my eyes on a white paper, than when I turn or rest them on my table, which is of dark mahogany.—I see them of a greyish colour, just as the images of objects seen under the microscope. These images are the shadow of the objects, projecting itself on the retina, which is brightly lighted up around them in the circular field of the microscope, just like *the Chinese shadows of the magic lantern*." In my opinion, adds M. Robin, it is not the retina which continues and recommences to act in the absence of the object; "it is the cerebral centre of visual perception," which having once acted, recommences two or three times to act of its own accord. "I do not think the external extremities of nerves of sensibility, or organs of impression, are capable of such spontaneous action as to transmit the form, colour, &c. of an object to the perceptive centre; but, on the other hand, the centre of perception itself may return spontaneously to a preceding state of activity, under the influence of some

temporary congestion of its vessels, such as is produced by the prolonged use of the microscope, or the ingestion of the alkaloids of opium, or of belladonna, absinthe, &c." In fact, diseases of the eye with congestion of the retina, but unaccompanied by meningitis, do not recall to the scene images of this kind, but entirely different ones; to arouse these, there must be meningitis, the intoxication of opium or absinthe, that is to say, irritation of the nervous centres.—To sum up, irritation of the nerves and that of the nervous centres are recognisable by symptoms of marked difference. "The first, which we may term pseudæsthesia of the peripheral extremities, is characterized by luminous sparks and flashes, by noises, ticklings," and other isolated sensations, not forming a system and not corresponding to any possible combination of external characters. "The second, which we may term pseudæsthesia of the perceptive centres," is characterized by the persistence or revival of complete images, like those of the microscope—that is to say, by hallucinations or spontaneous and organized sensations of colour and relief, of harmonized and articulate sounds, corresponding to a possible combination of external characters.

IV. We have then finally settled that the necessary and sufficient condition of the sensation and therefore of images, is a certain action or molecular movement of the nervous centres, that is to say, of the encephalon; in fact, all nerves of sensation terminate there, either directly, as is the case with the cranial nerves, or indirectly, as the rachidian nerves, through the medium of the conducting parts of the spinal marrow.*—We must now inquire, what among the different parts of the encephalon are those whose action is the necessary and sufficient condition of sensation and of images? For this purpose physiologists employ vivisections, and their experiments are very decisive in the matter. Let us first consider the pure sensation.

If the reader will examine a preparation of the encephalon,

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* Brown-Séquard, "Journal de Physiologie;" and see *ante* book iii. chapter 2, p. 136.

or at all events the figures of some large anatomical atlas, he will find that the spinal marrow at its upper extremity swells out into a bulb termed *Medulla Oblongata* or *rachidian bulb,* with which the encephalon commences. We may cut away from an animal the whole encephalon excepting this bulb; the animal will still execute a number of systematic and automatic movements, which are termed reflex, and which are produced by the different segments of the marrow without the intervention of the encephalon.* For instance, it swallows food, the muscles of its face still contract in an expressive manner, it articulates vocal sounds, and goes through all the movements of respiration; but it can no longer experience sensations strictly so called. It utters cries, but mechanically only; it no longer suffers pain. Let a transverse section be made above the bulb. "The bulb and marrow are then isolated from the encephalic centre, just as if the brain and annular protuberance were removed; this is what I do to this rat. I now pinch its paw; you hear a short slight cry. I do so again: another similar cry. I now wound deeply the rachidian bulb; I again pinch a hind limb: there are reflex movements, but there is no longer any cry. . . . . Observe the character of the cries you have just heard, they are *reflex cries,* and very different from cries indicating pain." There is in the bulb, as in the different segments of the marrow, a mechanism capable of acting, either directly by the irritation of the sensitive nerves it receives, or indirectly by the effect of the sensations aroused in the other parts of the encephalon. When the other parts are cut away, the bulb continues to act, and the cry is produced, without any sensation having been excited.—Let us next preserve, not only the rachidian bulb, but also the part of the encephalon adjoining it—the *Pons Varolii* or annular protuberance through which the fascia of the bulb pass, and remove the remaining parts, that is to say, the cerebral lobes, the corpora striata, the optic thalami, and the corpora quadrigemina.

* Vulpian, op. cit. 496, 510.

"When this is effected on dogs and rabbits, they manifest by violent agitation and *plaintive cries*, the pain they feel when the trigeminal nerve is pinched, or when they are subjected to keen external stimuli. If the protuberance be then deeply wounded, there are no more cries or agitation, even under violent pinchings; and yet the circulation, respiration, and other functions continue to be accomplished for some time. . . . . I have repeated M. Longet's experiments, and have obtained precisely the same results as his. This young rabbit has, strictly speaking, no brain, neither corpora striata, nor optic thalami; all there is left in its skull are the annular protuberance, the rachidian bulb, the cerebellum, and the corpora quadrigemina.* I pinch its tail sharply; you see it is at once violently agitated. I pinch its ear, its lip; similar agitation, and similar cries. Can these cries be considered as reflex phenomena?"—By no means. "You have seen animals from which the whole encephalon, excepting the rachidian bulb, has been removed; these animals continued to cry when pinched; but what a difference between their cries and those we hear when we have left the protuberance intact! In the first case, each excitation of a still sensible part excited a short cry, single for each separate excitation, always the same, and something like the sounds given out by children's toys when pressed in a certain way—in a word, deprived of all kind of signification. There we have the reflex cry. But here, with this rabbit, what a difference we find! When a sensible part is irritated the cry is not a short but a prolonged one, unmistakably plaintive, and, after a single excitation, the animal gives several successive cries, precisely similar to the cries of pain which another uninjured rabbit gives when it is subjected to sharp irritation."† Hence action of the protuberance is the necessary

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* Other experiments show that the cerebellum does not intervene in sensation; the functions of the corpora quadrigemina will be presently explained. Meanwhile this experiment may be considered as conclusive as if the cerebellum and corpora quadrigemina had also been removed.

† Vulpian, op. cit. 541. Experiments of Longet.

and suffieient condition of tactile sensations.—It is also the neeessary and sufficient condition of sensations of hearing. "A eertain call made with the lips, or a rough purring noise like that of an angry cat, will always startle an uninjured rat. Now here is a rat from which the brain, strictly so called, the corpora striata, and the optic thalami have been removed. You see him—he is very quiet; I make the noise I have just deseribed, and the animal at onee gives a sudden jump. Every time I make a similar noise, you see a similar jump. Those of you who have notieed the effects of being so startled upon an uninjured rat will reeognise that they are of preeisely the same eharaeter as we see here."*—Finally, the aetion of the protuberanee is also the neeessary and suffieient conditious of sensations of taste. "I have removed the eerebral lobes from kittens and puppies; and on pouring down their throats a concentrated deeoetion of eoloeynth, I have seen them go through abrupt motions of mastieation, and eontort their lips, as if to rid themselves of a disagreeable sensation. The same movements were observed in an uninjured animal of the same speeies, when forced to swallow the same bitter deeoetion."† There is, then, a speeial eentre, the protuberanee, whose aetion is the neeessary and suffieient condition of many kinds of sensations.—There are other similar eentres which perform the same offiee with respeet to other sensations. For the sensations of sight, they are the corpora quadrigemina or bigemina. "Here is a pigeon whose eerebral lobes are entirely removed, but whose corpora bigemina remain; when I suddenly put my hand near it, it makes a slight movement of the head to avoid the threatened danger. The sight then is retained. We have here a phenomenon analogous to that which we noticed in the ease of the rat deprived of its eerebral lobes, when we indueed a sudden jump by means of eertain sudden noises. Here again we have an example of sensations without the

* Vulpian, op. cit. 548.
† Longet, "Traité de Physiologie," ii. 243. Vulpian, 548.

intervention of the brain strictly so called."*—If, on the other hand, we leave intact the cerebral lobes, and injure or destroy the corpora quadrigemina, the animal becomes blind, preserving, nevertheless, all its ideas, its instincts, and its other sensations. The corpora quadrigemina, then, furnish by their action the sufficient and necessary condition of visual sensations, and of visual sensations only. —As to sensations of smell, experiments have not yet been made to determine the portion of encephalon whose action is their necessary and sufficient condition; but all anatomical and physiological analogies lead us to the belief that, for them, as for the other four kinds of sensations, there is a centre, distinct from the cerebral lobes themselves.— When excited by the action of the sensitive nerves, the cells of these centres perform their functions in an unknown manner, and this special molecular movement, without which there is no sensation, is in itself sufficient to arouse the sensation.

V. It must be observed that we have here been dealing with pure sensations, or with what physiologists call *crude unelaborated* sensations, that is to say, with sensations unprovided with the faculty of spontaneous revival, and therefore with the faculties of being associated, of forming fixed groups, and of furnishing means for the higher operations of intelligence. We must now look to another class of experiments, and here again the concordance of physiology with psychology is as complete as unforeseen. Psychological analysis had already separated the functions; physiological analysis separates the organs. The first placed on one side pure sensations, on the other images or reviving sensations; the second puts on one side the corpora quadrigemina, the protuberance, and perhaps another ganglion, whose activity arouses pure sensations, and on the other side the cerebral lobes, whose action arouses images, that is to say, reverberates, prolongs, and associates sensations.

If the reader will look again at a prepared encephalon,

* Vulpian, 557. Experiments of Flourens and Longet.

he will see that, from the anterior angles of the annular protuberance, spring two large white columns, called cerebral peduncles or *crura cerebri*, whose fibres terminate in the swellings called optic thalami and corpora striata, which are intermediate organs to the cerebral lobes and the protuberance. In fact, other fibres start from these organs and terminate in the cerebral lobes.* As to the cerebral lobes themselves, they constitute, particularly in the superior animals, the greatest part of the encephalon. In man they are enormous, and occupy by far the largest part of the cranium. Comparative anatomy has already foreshadowed their use by showing us that in the animal series their volume increases at the same rate as intelligence; we shall, moreover, find that their most important part is the outer layer, composed of a grey substance; and it is a no less significant circumstance that, as we ascend the zoological scale, this surface increases much more quickly than the volume owing to the very numerous swellings and anfractuosities which bend it into folds and are called circumvolutions.† In man himself, atrophy of the cerebral lobes and absence of circumvolutions are always accompanied with idiocy; "when a brain is below a certain volume and certain weight, it must necessarily have belonged to a person affected with imbecility . . .;" and, in general, if we compare different races of men, "the volume of the encephalon is in proportion to the degree of intelligence."—All these presumptions are confirmed by our operations on living animals; it is sufficient to resume the preceding experiments;‡ when we have removed the cerebral lobes, the rest of the encephalon being intact, pure sensations still, as we have seen, subsist; but they alone subsist. The animal still experiences crude sensations of light by means of the corpora quadrigemina, crude sensations of pain, contact, sound, and

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* Vulpian, 652, following Koelliker.

† Broca, "Sur le Volume et la Forme du Cerveau, suivant les individus et suivant les Races." Paris, 1861.

‡ Vulpian, 690. Flourens, 2mo édition, "Recherches Expérimentales sur les Propriétés et les Fonctions du Système Nerveux," 24.

taste, by means of the protuberanec. But these are bare sensations; they are not, as in the normal state, accompanied and clothed with associated images, which add to the sensation of light notions of the relief, distanee, and other charaeters of the luminous objeet; to the sensation of contaet, notions of situation, resistance, and form; to the sensation of sound or taste, the representation of a sonorous or savoury body. Much less then, ean these isolated sensations arouse the assoeiated images eonstituting memory and prevision, and through them judgments, and all the assemblage of emotions, desires, fears, and determinations developed by the notion of approaching danger or of future pleasure.

Another eonsequence is the absenee of instinets; for instinets are eonstituted by groups of images whose association is innate. A beaver shut up in an enclosure in the Jardin des Plantes, who eolleets pieces of wood and mortar to make a dam of which he has no need in Paris, and of whieh he has need in Ameriea, is an animal in whom are developed a spontaneous system of images; so, again, is a bird who builds his nest in the spring; at the sight of straw, hair, and wool, the notions of their eombination and usage arise in him without preliminary experience, without tentative effort, in a fully constructed order, by an unacquired wisdom. It matters little whether this order be, as with man, the effeet of a personal apprentieeship, or, as with the brutes, the play of an hereditary meehanism; it is invariably an order of representations—that is to say, of grouped images; and therefore, if the images are destroyed, it is destroyed.

This is what happens when the eerebral lobes are eut away. "The animal loses all its intelligence." Though, with the eorpora quadrigemina and protuberanee, it may have retained crude sensations, it no longer has the images whieh by their association with erude sensations give it the notion of objeets. "These objects eontinue to paint themselves on the retina; the iris remains eontraetile, the optic nerve excitable; the retina remains sensible to light; for the iris eontracts or expands aeeordingly as the light is more or less vivid; so the eye is sensible. And still the

animal no longer sees. . . . . ." A pigeon thus operated on "kept itself well upright; it flew when thrown in the air; it walked when pushed on from behind; the iris of its eyes was very contractile; nevertheless, it did not see or hear, it never moved spontaneously, it put on all the attitudes of a sleeping or drowsy animal, and when roused from this sort of lethargy, assumed the attitude of an animal waking up. . . . . When I let it alone, it remained calm and as it were absorbed; in no one case did it give signs of will. In short, picture to yourself an animal condemned to perpetual sleep, *and deprived of the faculty of dreaming in this sleep.*" In fact, all the images whose irregular concatenation forms dreams, and whose regular coneatenation forms the waking state, were absent; all that remained were some few intermittent sensations aroused by the experimenter, and, accompanying them, the dull tendencies and involuntary movements consecutive to them.—A hen lived ten months after a mutilation of this kind, and, after the fifth month, was fat, strong, and healthy; but instincts, memory, prevision, and judgment were gone. "I left her fasting on many occasions for three whole days at a time, and then have put food to her nostrils, have dipped her beak in grain, have placed grain in the anterior part of her beak, plunged her beak in water, placed her on a heap of corn. She did not smell, or swallow, or drink, she remained motionless on the heap of corn, and would assuredly have died there of starvation if I had not taken on me to make her eat. I have twenty times put pebbles instead of grain in her beak; she swallowed the pebbles as she had swallowed the grain.* Finally, when she met with an obstacle in her way, she ran against it, and the shock stopped her or shook her. But to run against an object is not to feel it; she never groped about or hesitated in her progress. . . . . She never took shelter, however inclement might be the weather; she never defended herself against the other fowls; she no longer knew how to fight or to run away; the caresses of the male bird were indifferent

* By a reflex movement.

or unperceived by her. . . . She ceased to peck with her bill."

The same thing happens with other animals.* Frogs have no longer any notion of eating a fly held to their mouths. "The mole ceases to dig, the cat remains quiet even if teased." All images, then, fail, and consequently, those which serve as signs, and by which we have abstract ideas, also perish. Thus all the operations which pass beyond pure sensation—not only those which are common to animals with man, but also those which are special to man—have, for sufficient and necessary condition, an action of the cerebral lobes. They are, then, attached to this action; they rise, perish, are altered, are accelerated and transformed with it, and pathology here is in accordance with viviseetion.

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* Vulpian, 690. Landry, "Paralysies," 82.

If we take two frogs, one uninjured and the other deprived for some days of its cerebral tubercles.

"Let them both be put on the floor, the first runs off at once and tries to hide himself. The second, after a leap or two, becomes motionless and remains so. When a noise is made near them, the first will sometimes turn round to see where it comes from and sometimes run away, the second will give a slight start, but will not move. If their paws are pinched they will both jump away, and struggle if they are retained."

Let them both be put in a large basin of water.

The *uninjured frog* goes through several movements of swimming, and tries to hide himself at the bottom of the basin. Meanwhile, *the movements of respiration have entirely ceased.* After a time, it regains the surface of the water in order to breathe, and tries to remain there, but having no hold exhausts itself in its efforts to keep there. When pushed down to the bottom, it soon comes up again, and if prevented from doing so, will attempt to come up at another part of the basin.

The *frog deprived of its brain* behaves very differently. The moment it is placed in the basin it sinks to the bottom like an inert mass without attempting to swim. Still, when stirred with a stick, it goes through the movements of swimming, but at hazard and without object, and then becomes motionless and sinks to the bottom. In its case *the respiratory movements continue to be gone through as in the air*, with the single difference that the little membranous lid of the nostrils is completely closed. The animal remains quietly at the bottom of the basin without attempting to gain the surface to breathe, and without showing the least uneasiness. The respiratory movements "become abrupt and few, and the frog dies suffocated without having made any attempt to breathe, and without appearing to have suffered.

"Thus the brainless frog does not know how to suspend respiration, and would inspire water if the lid of the nostrils did not close automatically at the contact of the liquid; it does not suffer from asphyxia, is not aware of it, and does not attempt to avoid it. Nothing, it seems to me, can better show than this experiment both the real absence of perception, the absence of every intellectual phenomenon, and the absence of will.

"I admit with M. Flourens that the brain properly so called is the seat of perception, volition, and all intellectual phenomena."

"All the organs," says Mueller, "with the exception of the brain, may either pass slowly out of the circle of the animal economy or perish, without the faculties of the mind undergoing any alteration. It is different with the brain; any cause which disturbs its action slowly or suddenly, affects at the same time the mind. . . . . Inflammation of the brain is never unattended with delirium, and at a later period with stupor; pressure on the cerebrum, whether produced by depressed bone, foreign bodies, serum, blood or pus, always gives rise to delirium or stupor, according as there is or is not irritation with the pressure. The same causes, according to the seat of their action, frequently abolish the power of voluntary motion, or memory; and when the pressure is removed, the memory frequently returns, and it has been observed that the chain of thought was immediately resumed at the point where it was interrupted by the injury."* After cerebral commotion "there is sometimes complete loss of intelligence. In other cases the patient answers questions put to him, but soon falls again into a drowsy state, his memory is sometimes entirely, sometimes partially gone. Total forgetfulness of a foreign language is one of the most usual effects of this commotion. . . . . Patients never recollect how their accident has occurred; if they have fallen from horseback, they recollect perfectly having mounted and got off, but never recollect the circumstances of their fall. The effects of a lesion of the brain are in some ways analogous to those brought on by old age; the patient preserves the recollection of recent impressions only, and forgets those of earlier date. . . . With some patients, memory remains ever after imperfect . . . In some particular cases patients are unable to avail themselves of the right word to express their ideas, the judgment is often impaired."†— Other injuries indirectly affecting the brain produce similar effects; we know that people faint when

* Mueller, op. cit. (tr. Baly) i. 817.
† Vidal, "Pathologie Externe," 750—citing Cooper.

they have lost much blood, that drunkenness disorders the ideas, that narcotics produce stupefaction, haschich brings on hallucinations, coffee developes a liveliness of mind, chloroform and ether produce insensibility."*—To sum up, alteration of the cerebral lobes has, as a consequence, a proportionate alteration of our images. If the lobes become unfitted for some particular system of actions, some particular system of images, and therefore some group of ideas or of cognitions, is found wanting. If their action becomes excessive, images of a more intense kind escape from the repression ordinarily imposed on them by sensations, and turn into hallucinations. If, in addition to this, their action becomes disconcerted, images lose their ordinary associations, and delirium is pronounced. If their action be annulled, all images, and therefore all ideas and cognitions, are annulled; the patient falls into the state of torpidity and deep stupor which we find caused in animals by cutting away these lobes.

VI. We must now determine on what part of the cerebral lobes images depend. These lobes are made up of a white substance and grey cortical matter; and all inductions concur in attributing images to the action of the grey cortical matter. In fact, the extent of this cortical matter is augmented by that of the convolutions, and comparative anatomy shows us that, in the animal kingdom, intelligence increases with the extent of the convolutions. Physiology again proves that in other parts of the nervous system the white substance is simply conductive.† According to all indications, that of the brain has no other function. "It is evident that here, as in all other parts of the nervous system, the special activity belongs to the

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* Longet, ii. 36. The above theory may be verified by the process of etherisation. This process has two stages. In the first, the animal etherised (dog or rabbit), loses its intelligence, its will, its instincts, and all its faculties with the exception of its crude sensations. In this stage there is etherisation of the cerebral lobes and other parts of the encephalon, but not of the protuberance and bulb.—In the following stage the animal also loses its sensations. There is then etherisation of the annular protuberance.

† Vulpian, 646, 669.

grey substance. Pathological observations are equally conclusive. . . . . Whilst lesions of the cerebellum, of the optic thalami, of the corpora striata, in fact of *the white medullary masses of the cerebral lobes*, do not ordinarily occasion any permanent or clearly marked disturbance of the intellectual functions, extensive alterations of the grey substance of the convolutions, or morbid excitation of this substance, necessarily occasion weakening or exaltation of these functions according to the nature of the alteration and the stage at which it has arrived. Thus we can explain the effects of diffused meningo-cephalitis and of simple meningitis. The centre of cerebral activity being thus clearly ascertained, it is not permissible to doubt that we have here the true starting point of dementia and mania."

This grey cortical matter is composed of several layers, which are alternately grey and white :* "We see in them nuclei, and very many multipolar nervous cells of small dimensions;" a quantity of fibres connect together different regions of the grey layer of the same lobe, and those of one lobe with the other; other fibres connect the whole surface of the grey matter with the corpora striata and optic thalami. When transmitted by the fibres of the optic thalami and corpora striata, the action, which in the corpora quadrigemina and annular protuberance had aroused a crude sensation, passes on by the fibres of the white substance to the cells of the cortical matter of the cerebrum, and propagates itself, by the intermediary fibres, from one point to another of the grey substance; this action of the cortical cells is the necessary and sufficient condition of images, and consequently of all cognitions or ideas.—The scalpel, the microscope, and physiological observation can go no further than this without falling into hypotheses; we can neither define this action nor explain this propagation, and all we know is that there is a molecular movement in the case. But vivisections and the history of wounds of the head here afford new evidence, which, combined with the former,

* According to M. Baillarger—Vulpian, 644.

enables us to gain a general view of the functions of the brain. It is *a repeating and multiplying organ,* in which all the different departments of the grey cortical matter fulfil the same functions.

In the first place, "it is easy to prove by instances that with an absence we may term complete of one cerebral hemisphere, a man may still enjoy all his intellectual faculties and even all his external senses. . . . . This was the case with one Vaequerie, in 1821. He was hemiplegic on the left side, but his intellectual functions were intact. At the autopsy, a quantity of serum was found filling the place of the right hemisphere; the cerebral substance on that side had disappeared."*—Not only does one hemisphere supply the place of the other, but any one region of the brain, if sufficiently large, may supply the place of another; the proof of this lies in the fact that any portion may be wanting without any of the mental faculties being missed.† The disorganized or destroyed portion may belong to the anterior or to the posterior lobes of the brain; it is of little consequence. "Bérard reports a case in which the two anterior lobes were crushed, while reason, sensibility, and voluntary movements were retained." "An officer had received a ball that had entered one temple and passed out at the other; the wounded man, who died very suddenly three months afterwards, was observed till then, and, during all that time, not only did he enjoy his full intelligence, but showed unusual cheerfulness and serenity in the intercourse of life."‡ After the battle of Landrecies, "twelve men had received wounds at the top of their heads, as large as the palm of the hand, with loss of

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* Longet, "Anatomie and Physiologie du Système Nerveux," 666, 669. And see Vulpian, 707. The same result is observed in pigeons when one hemisphere has been removed. They preserve or regain all their faculties.

† Longet, ibid. Vulpian, 711.

‡ See "Bulletin de l'Académie de Medecine," x. 6, for an analogous case of a child four years and a half old, through both of whose temples a ball had passed, and who nevertheless lived twenty-six days, enjoying the whole of its intellectual faculties, with complete memory, sound judgment, and with its character unaffected by the injury.

substance of integument, bone, dura mater, and brain. These wounds were occasioned by horizontal sabre-cuts. They had all travelled more than thirty leagues before their wounds were dressed, sometimes on foot, sometimes in wretched cars, and went on favourably till the seventeenth day. They preserved their appetite, their strength, and even their martial appearance."* . . . . Such, again, is the case of the dragoon mentioned by Lamotte, who "had lost by a sabre-cut a piece of the right parietal bone two inches long, and three or four inches of the left parietal bone, down nearly to the ear. This wound, which comprised not only the membranes of the brain but the longitudinal sinus and the brain itself, was followed by syncope, consequent on the loss of blood, but gave rise to no serious ill effects,† and was cured in two months and a half. Lamotte is not the only one who has observed cases of this kind, for they are not very uncommon."— All the mutilations practised on animals lead to the same conclusion. "We may remove a considerable portion of the cerebral lobes, either in front or behind, above or below, without their functions being lost. A very small portion, then, of these lobes is sufficient for the exercise of their functions. In proportion as the removal goes on, all the functions are weakened and gradually become extinct, and, when certain limits are passed, they become actually extinct. . . . . Whenever one perception is lost, all are lost; whenever one faculty disappears, they all disappear. . . . .

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* Nélaton, "Patbologie Externe," iii. 572.—Vidal, "Pathologie Externe," ii. 744.

† Cf. Karl Vogt, "Leçons sur l'Homme," 127.

"If we gradually, layer by layer, remove the cerebral lobes in an animal, the different phenomena of increasing stupidity become more and more evident, without our being able to determine a special action in any one direction.—The removal of half the brain seems to have no appreciable influence, which shows that, for some time at least, the other entire half is able to supply the place of the missing half. Still, we observe that the functions exhaust themselves more quickly than when the brain is entire, which shows that the operation influences the quantity, not the quality, of the manifestations of the organ. Several observations have been collected of men who, after deep lateral wounds of the head, followed by loss of cerebral substance, have experienced no diminution of their faculties, but *were speedily exhausted, and compelled, after short intellectual labour, to stop and abandon themselves to complete repose or even to sleep.*"

Provided the loss of substance occasioned to the cerebral lobes does not exceed certain limits, these lobes regain after a time the exercise of their functions; when these first limits are passed, the functions are but imperfectly recovered, and, when the new limits are also passed, the functions are not recovered at all. In short, as soon as one perception returns, they all return, and as soon as one faculty reappears, they all reappear."* A frog, which had only a fragment left of its posterior lobes, amounting to about an eighth of the whole brain, had preserved the appearance of a healthy frog. "Five weeks afterwards, a large fly, with one wing removed, was put into its basin. As soon as the fly was in the basin, the frog changed its attitude, and seemed to watch the insect, and, as soon as it came near, made a short jump and tried to catch it with its tongue; but it did not succeed the first time, and was obliged to recommence the movement of projecting its tongue; this time it succeeded. On the following days, other flies were given it, and it seized them at the first attempt. . . . The only alteration observed in its movements was, that it was a little less lively; and again, it did not attempt, like other frogs, to escape from the hand put out to catch it. . . . . On the contrary, when the brain is completely removed, there is not the least attempt on the part of the frogs to take flies which are given them; and they do not even swallow the flies till placed at the back of their mouths."—We see that in the case of the first frog the eighth part of its brain supplied the place of the rest; a larger portion would be required in the case of a superior animal, and, when we come to the summit of the animal kingdom, the mutual dependence of the different parts of the brain is much greater. But the conclusion is still the same. The brain is a kind of polypus, whose elements have the same functions. We cannot say with precision how many cells and fibres are required to form one of these elements; but each of these elements is

* Flourens, "Recherches Expérimentales," &c., 99.—Vulpian, 709 (Experiments on Fowls and Pigeons).

capable, by its action, of giving rise to all normal images and all their associations, and consequently to all the operations of the mind.

Having settled this, we can, by aid of psychology, take a step in advance. We know that all ideas, all cognitions, all the operations of the mind, are composed of associated images, that all these associations depend on the property of images to revive, and that images themselves are sensations reviving spontaneously. All this agrees with the teaching of physiology. An action is produced in the sensitive centres strictly so called, protuberance, or corpora quadrigemina; it there excites a primary or crude sensation. An *exactly similar* action is consequently developed in a cortical element of the cerebral lobes, and there excites a secondary sensation or image. The first action is incapable, and the second is capable of reviving spontaneously; consequently the crude sensation is incapable, and the image is capable of reviving spontaneously. The more extensive is the cortical matter of the brain, the more elements has it capable of setting one another in action; the more elements it has capable of setting one another in action, the more delicate an instrument of *repetition* it is. The brain, then, is the *repeater* of the sensitive centres; such is its office; and it will the better fulfil this office the more numerous the repeaters of which it is itself composed.

Here we perceive the mechanism which renders possible the fundamental property of images—I mean, their aptitude for endurance and revival. As the brain is made up of similar mutually-excitable elements, the action of the protuberance, of the corpora quadrigemina, and in general of the centres of sensation, once repeated by one of its elements, is transmitted in turn to the rest, and may thus revive indefinitely. Imagine a series of vibrating strings disposed in such a way that the movement of the first is communicated from string to string up to the last, and reverts from this last to the first; the illustration is homely but clear. Such is the action which runs through the similar elements of the brain; and thus, in the absence of all external excita-

tion, it lasts on, being effaced, reviving, and so persisting indefinitely through a series of extinctions and revivals. Such too is the image, and we have but to refer back to its history to see it endure, become effaced, and reappear in precisely the same manner.—Assuming now that, by a new excitation of the centres of sensation, a different action is produced in one of the cerebral elements; according to the law of communication, it must pass in turn to the other elements, and we shall have a different image which will persist like the first, while becoming weaker and stronger by turns. But the same cerebral element cannot be in two different states at the same time, and consequently cannot produce two different actions at the same time. The cerebral elements, then, will be drawn in two different directions, and, as the two actions are incompatible, one alone will be propagated.

Which of them will be propagated? There are conditions which incline the balance to the one side or the other. Of the two tendencies, one or the other will prevail.* We have seen the laws which confer ascendancy on images and deprive them of it, and these are precisely the ones which determine the propagation of such or such a particular action. Images strive together for predominance, and so cerebral actions strive together for propagation. At any given moment some one action will be propagated, and will give the ascendancy to some image, and will then make way for another action, which, propagated in its turn, brings on the scene another image. Thus images succeed one another, and become preponderant in proportion as the action producing them is propagated through a greater number of elements.

It must be observed that this presence of an image is nothing more than its preponderance; it is considerably stronger than the others, that is all; but it does not exclude the others; on the contrary, they still persist in a rudi-

* See ante, Book II. chap. ii. "Laws of the Revival and Obliteration of Images."

mentary and latent state; and this obscure persistence may be observed at any moment.—You have sung over, some fifteen or twenty times in succession, a new air which has impressed you a great deal; you are interrupted for some little household occupation, or by some tiresome visit; on this, another series of sensations, images, and ideas unrolls itself perforce within you; but the first, though it has yielded its place, has not been destroyed. It is pushed back, reduced; it permits the others to occupy the foremost place and to obtrude themselves on the attention; but though retired and driven back into the distance and shade, it still exists. You will find it there as soon as you revert to it; it will spring again to the light of its own accord as soon as the intruders have gone. The evidence of its secret persistence lies in the disturbance, the uneasiness, the dull tendencies which you have felt all the time and which its obscure presence excites in you.—So again, you hear news, good or bad, and after an hour you have ceased to think of it; but nevertheless, after the hour and perhaps for the whole day, you still feel an ill-defined pleasure or inquietude which you cannot explain at first sight, and which you do not understand till you reflect, and the recollection of the news returns.—Among latent images or ideas, we must also reckon those of all the actions we carry out while our minds are occupied by some other preponderant image or idea. For example, we follow out a thought as we walk along; we follow the tune of the piece we are playing, all the while we are playing it; we follow the argument of an author while we are reading him aloud. In these different cases, the images of the muscular movements we wish to accomplish must be present to our minds, since the muscular movements are accomplished; but their series is not observed because another series is preponderant.—This is the constant state of our minds, a dominant image, in the full light, and extended around it, a constellation of fading images, growing more and more imperceptible; beyond these, a milky way of images wholly invisible, of which we have no other consciousness than by the effect of their mass, that is to say,

by our general feelings of gaiety or sadness. Every image may pass through all the different states of light and dimness; at a certain limit, it escapes from consciousness, but it is not therefore extinguished, and we do not know to what degree of obliteration it may possibly descend.—The scale of these degrees descends to a marvellous depth; it is enough, to convince oneself of this, to observe the revivals of images* taking place after twenty, thirty, and fifty years' interruption, and the abnormal reproductions of transient experiences which seemed to have left no trace behind them. We find here the same law as in the case of sensations proper; the image of which we are conscious is but a *whole* whose elements may be infinitesimal.

Having determined this, we conceive the corresponding cerebral process, and further, by this comparison, we understand how there may be images within us of which we have no consciousness. When an image is preponderant, the action corresponding to it is propagated through the greater part of the similar cerebral elements; but through the greater part only. Without this vortex are other elements, in which a different action may be propagated at the same moment, whose whole intensity is less, since the number of its factors is smaller; to this action of less intensity corresponds the accessory image, of less intensity, all but invisible to consciousness, and which we can only perceive indirectly, in the background. Let the number of factors again diminish, the intensity of the action, and, therefore, the intensity of the image will diminish proportionately; a moment will arrive at which the image will be wholly without the range of consciousness, and nevertheless still capable of as many degrees of progressive weakening as the number of its factors is capable of reductions. The series of these degrees and of these reductions may be enormous, and we can conceive that, in addition to secondary and tertiary images, whose presence we may still distinguish

* "Laws of the Revival and Obliteration of Images." See for different instances ante, Book II. chap. ii. pp. 76, 77.

or divine, there are images again still more enfeebled, below these, others still more so, and so on, till we come to those aroused by the action of a single cerebral element. Similarly we can conceive that the same image, having been for a moment preponderant, may be effaced by degrees, may subsist for a long time without our having had consciousness of it, then, of a sudden, to our great surprise, may reappear in full light, according to the more or less extended ascendancy of the corresponding action, which, propagated at first through the majority of the cerebral elements, becomes more and more limited, is contracted and grows thinner, then, later on, reassumes the ascendancy by the sudden appearance of some unforeseen sensation which renews one of its fragments.

VII. We now know exactly the physical conditions of our mental events; the condition of our crude sensations* is a certain action or molecular movement of the protuberance of the corpora quadrigemina, and, in general, of some primary centre of the encephalon; the condition of our images, ideas, and the rest, is the same molecular movement repeated and propagated in the elements of the grey cortical matter of the brain. On this molecular movement depend the events which we refer to our personality; if the movement exists, they exist; if it is missing, they are missing. There is no exception to this rule; the loftiest thought, the most abstract conception, is subject to it, through the words or signs which serve as its foundation. Every idea, voluntary or not, clear or obscure, complex or simple, fugitive or persistent, implies a determinate molecular movement in the cerebral cells.—But, besides the mental events perceptible to consciousness, the molecular movements of the nervous centres also arouse mental events imperceptible to consciousness. These are far more numerous than the

* Vulpian, 681.—"It is a notion of extreme importance in physiology and philosophy, that in every complete sensation there are two wholly distinct phenomena, so distinct that they are seated in two different parts of the nervous system. The one is the sensation strictly so called, and has as its seat the isthmus of the encephalon, and in part, the annular protuberance. The other is the intellectual elaboration of the sensation, and takes place in the brain properly so called."

others, and of the world which makes up our being, we only perceive the highest points, the lighted-up peaks of a continent whose lower levels remain in the shade. Beneath ordinary sensations are their components, that is to say, the elementary sensations which must be combined into groups to reach our consciousness. By the side of ordinary images and ideas, are their collaterals, I mean the latent images and ideas, which must take their turn of preponderance and ascendancy in order to reach consciousness.

Having settled this, we see the moral world extending far beyond the limits assigned to it. We are accustomed to limit it to events of which we have consciousness; but it is now plain that the capacity of appearing to consciousness belongs only to certain of these events; the majority of them do not possess it. Outside a little luminous circle, lies a large ring of twilight, and beyond this an indefinite night; but the events of this twilight and this night are as real as those within the luminous circle. Hence it follows that, if we find elsewhere a nervous structure, excitations, reactions, in short all the accompaniments and the physical indications we meet with in the mental events of which we have consciousness, we shall have a right here also to conclude the presence of moral events to which consciousness does not attain.

This is the case with *reflex* phenomena, one of the most instructive instances physiology presents. There is in a living body another centre besides the encephalon; that is the spinal marrow; this marrow, like the encephalon, comprises a grey substance, which, like that of the encephalon, is a terminus of transmitted excitations, and a starting-point for reflected excitations. There is produced in it, as in the encephalon, an unknown molecular movement, which is excited by the action of the sensitive nerves, and excites the action of the motor nerves, and which, according to all analogies, arouses, like the molecular movement of the brain, an event of the mental order.—In fact, the action it gives rise to in the motor nerves is not irregular;* "it is appropriate

* Vulpian, 414 et seq.

and adapted;" it seems "intentional." In every case, it tends to an object, "even when the animal is deprived of its encephalon," and this so perfectly, that many physiologists have admitted a soul, or at least, "a perceptive and psychical centre," in the segment of marrow thus cut off.—"Here is a Triton, whose head, with the anterior part of the body and the two corresponding limbs, have been removed by a transverse section. I pinch the skin of the lateral parts of the body; there is, as you see, a movement of lateral curvature of the body, producing a concavity of the irritated side, and it is plain that the result of the movement is to remove the irritated part away from the object irritating it. Now, this is the precise movement which we see in unmutilated Tritons when subjected to a similar irritation. . . . . If they do not succeed by this means, they attempt to rid themselves of the irritating object by another plan which this mutilated Triton will also put into execution. You see, in fact, a movement takes place of the hind limb on the irritated side." The movements alter according to the point irritated, and the new combination of muscular movements is always one adapted to avoid the new cause of irritation. "All these movements are so well adapted and natural, that, if the wound caused by the decapitation were not apparent, you would think the animal had undergone no mutilation, and the common character of these movements is that their effect is defence against attacks from without."

So too, frogs when behcaded, can still leap and swim. Further, "if we put a drop of acetic acid on the upper part of the thigh of a decapitated frog, the hind limb bends in such a way that the foot rubs against the irritated part." The foot is amputated and the experiment repeated. "The animal begins new movements to rub the irritated part; but he cannot reach it, and after some movements of agitation, as if he were seeking a new mode of accomplishing his design, he bends the other limb, and thus succeeds in doing so."—These are the most salient experiments, and it will be comprehended that, to obtain such striking facts, we must operate on the lower animals, whose life is more tenacious,

and whose parts are less strictly connected with one another. —But similar ones are met with among the mammalia and even in man.* Cases have been seen "of anencephalous fœtuses, who cried and sucked a finger placed to their lips. Beyer, being compelled once to open the head of a fœtus to accomplish a delivery, and having completely emptied the skull, saw the fœtus, some minutes after birth, give a cry, breathe, and move its hands and feet."—With the higher animals, if we suppress the whole of the encephalon—that is to say, all the nervous centres with which sensations and images, strictly so called, are connected—the spinal marrow and bulb, which alone remain, are still capable, under the stimulus of the sensitive nerves, of exciting and combining movements with some object in view, as happens with the posterior limbs of a frog or Triton. The animal still cries, though without pain, when its paw is pinched; it swallows food when placed at the end of its gullet; it goes through all the movements of respiration. In our own cases, sneezing, coughing, vomiting, are so many systematically complex and useful movements, excited, without exercise of will on our parts, through the medium of the bulb.†—In general, given in an animal a segment of spinal marrow, with the sensitive nerves terminating in it, and the motor nerves springing from it, when the sensitive nerves are excited, the segment, commencing to act, will set to work the motor nerves, and we shall see muscular contractions. This may be readily observed in eels, salamanders, and serpents. Landry‡ observed it in sucking pigs, whose spinal marrow he divided into several segments, while leaving the rest of the body intact. Animals thus treated may live a long time, and, while the circulation subsists, "the reflex excitability of a separated portion of the marrow may persist almost indefinitely;" it has been seen to last three months, and even for more than a year.

Every segment then is a sort of complete animal, capable

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* Vulpian, 396. † Vulpian, 423.
‡ "Des Paralysies," 47. Experiments, 6, 7, 8. Vulpian, 432.

in itself of being excited and of reacting, capable even of living in an isolated state, if, as is the case with the inferior animals, and notably with the annelidæ, the mutual dependence of the segments is not too great.*—We should never come to an end if we attempted to enumerate all the cases of reflex action. The majority of the muscular movements of animal and of organic life, whether intermittent or continuous, are accomplished by it alone, so that we are obliged to consider all the central parts of the nervous system, encephalon, bulb, spinal marrow, as constantly set in action by the play of sensitive nerves, in such a way as to excite the play of motor nerves, with an accompaniment of sensations of which we are or are not conscious. Whatever be the portion of the nervous system observed, we never see in it any other than reflex actions; they may be more or less complex, but are always of the same kind. A white conducting cord conveys an excitation to a central nucleus of grey substance; a molecular movement then arises in this substance, and thereupon an excitation is carried on to the muscles by another white conducting cord. These three movements so connected constitute reflex action; the grey substance, wherever it be, in spinal marrow, protuberance, or cerebral lobes, always acts in the same way.

Now, in the protuberance and the cerebral lobes, its action arouses mental events, all of the same kind, tempo-

* Landry, "Paralysies," 47. The spinal marrow may be divided perpendicularly to its axis in two, three, four, or more segments, without inducing any modification of the phenomena in which it takes part.—Each one of these parts, anatomically constituted like the whole organ, possesses separately the same faculties. I have shown by experiments 9, 7, and 8, that a simple transversal section of the marrow, though it interrupts its continuity, leaves the reflex power, the excitability of the nerves, the contractility and nutrition of the muscles, still subsisting, in all the parts whose sensibility and movement are paralysed. . . . . Every segment of the marrow then is a real centre of innervation. . . . . Thus we may consider the medullary cord as made up of a series of nervous centres with identical properties, but affected nevertheless with different functions according to the different organs with which the nerves springing from it are connected. . . . . This would be in accordance with comparative anatomy, which shows that the marrow becomes gradually segmentary as we descend from the mammalia to fish, and from these to animals still lower in the scale, to the crustacea or instance. . . . . "

rary sensations or reviving sensations. We must, then, admit that its action excites everywhere mental events of an allied kind; and inasmuch as, even in the protuberance and lobes, the greater part of these events are imperceptible to consciousness, there is nothing to prevent its action from arousing, in the marrow, mental events analogous to sensation, but now situated, by nature not by accident, beyond the reach of consciousness.—We should thus have three degrees in sensation. In the highest degree, in the cerebral lobes, the sensation becomes capable of revival, and is termed an image. In the next degree, in the protuberance, the sensation, incapable of revival, remains simply crude. In the lowest degree, in the marrow, it is in a still more incomplete state, and we cannot now define it exactly from our having no consciousness of it, but we recognise it correctly by this incapacity to appear, and it probably resembles those elementary sensations which, when separate, amount to nothing as far as consciousness is concerned, and only make up an ordinary sensation by combining with others to constitute a whole.—So too there would be three degrees of complication in the action of the nervous centres. At the lowest degree, in the marrow, would arise fragmentary actions analogous perhaps to those which excite elementary sensations, imperceptible to consciousness. In the next degree, in the protuberance, these same actions combine, when transmitted, into a total action exciting the ordinary total sensation. In the highest degree, in the lobes, this total action, transmitted a second time, is repeated indefinitely by a series of mutually excitable cerebral elements, and then excites those secondary and reviving sensations we term images.—We thus conceive, for the action of the nervous centres as for mental events, three stages of successive transmission and elaboration, and we can thus include in a general view the reciprocal dependence and the development of the two streams.

They form two long series, the one of which is the necessary and sufficient condition of the other, and which correspond as precisely as the convexity and concavity of

the same curve. On the one side are the molecular movements of the nervous centres; on the other are mental events, all more or less analogous to sensation. The first invariably excite the second, and the degree of complication found in the one series always corresponds to an equal degree of complication in the other.—At a certain degree, the second series may be known by a special inward process we term consciousness; but, even when at this degree, it generally happens that the events of this series are not thus known.—Beneath those which consciousness attains, there are many others to which it cannot attain, and which we are compelled to conceive on the type of those we know, but on a reduced and fragmentary type, and becoming more reduced and fragmentary as the nervous action exciting them becomes more simple.—Thus we see that, beneath the ordinary sensations which we know by consciousness, there descends an indefinite series of analogous mental events, more and more imperfect, more and more removed from consciousness, without our being able to put a limit to this series of increasing degradations; and this successive lowering, which has its counterpart in the attenuation of the nervous system, leads us to the foot of the zoological scale, while connecting together, by a continuous sequence of intermediate links, the most rudimentary outlines and highest combinations of the nervous system and the mental world.

CHAPTER II.

RELATIONS OF THE FUNCTIONS OF THE NERVOUS CENTRES AND MENTAL EVENTS.

I. Here we have the great question of the physical and the moral world, two worlds which the most obvious experience shows to be inseparably connected together, and which their representations show us as absolutely irreducible to one another. On the one hand, we prove that the second depends on the first; on the other hand, we are unable to conceive that it so depends.—Physiologists, on the one hand, willingly lose sight of the second fact, and tell us that "mental events are a function of the nervous centres, just as muscular contraction is a function of the muscles, and the secretion of bile, a function of the liver." Philosophers, on the other hand, willingly lose sight of the first fact, and tell us that "mental events have nothing in common with the molecular movements of the nervous centres, and appertain to a being of different nature."—On this, cautious lookers-on interpose and conclude that:—"It is true that mental events and the molecular movements of the nervous centres are inseparably connected together; it is true that as far as our mind and powers of conception are concerned they are absolutely irreducible to one another. We stop at this difficulty, and will not even attempt to surmount it; let us content ourselves with ignorance."—For our own parts, if we attempt to make an advance into this obscurity, it is because we have already made several advances. On the one hand, we have seen that our most abstract ideas, being signs, are reduced to images, that our images themselves are reviving sensations, that consequently our whole entire thought is reduced to sensations. The difficulty then is simplified, and it is now a question only of

comprehending the connexion between a molecular movement and a sensation.—On the other hand, we have seen that sensations, though apparently simple, are wholes; that these wholes, though apparently irreducible to one another, may be composed of similar elements; that at a certain degree of simplicity these elements are no longer perceived by consciousness; that the sensation is then a compound of rudimentary events, capable of indefinite degradations, incapable of coming within the grasp of consciousness, but whose presence, and further, whose effectiveness is proved by reflex actions. The difficulty is thus simplified a second time; it is now a question only of comprehending the connexion between these events and a molecular movement. The obscurity still remains very great; for we can never conceive these events otherwise than after the type of ordinary sensations, and between this conception and that of a movement, is still a gulf. But we know that ordinary sensation is a compound, that it differs from its elements, that these elements escape our consciousness, that they are none the less real and active, and, in this deep lower twilight whence the sensation arises, we shall perhaps discover the link between the physical and the moral world.

II. Let us begin by stating the difficulty in all its force. Since mental events are nothing more than sensations more or less twisted and transformed, let us compare a sensation with a molecular movement of the nervous centres. Let us take the sensation of golden yellow, that of a musical note like *ut*, that given by the emanations of a lily, by the taste of sugar, by the pain of a cut, by tickling, by heat or cold. The necessary and sufficient condition of such a sensation, is an internal movement in the grey substance of the protuberance of the corpora quadrigemina, in short, of a centre of sensation; this movement may be unknown, it matters little; whatever it may be, it consists of a more or less complex and extensive displacement of molecules, and is nothing more.—Now, what relationship can we imagine between this displacement and a sensation? Cells, constituted of a membrane and one or more nuclei,

are strewed in a granulated substance, a kind of flabby pulp or greyish jelly, made up of nuclei and of innumerable fibres; these cells ramify into slender prolongations, which probably connect themselves with the nervous fibres, and it is supposed that they thereby communicate with one another, and with the white conductive parts. Study as closely as you will the anatomical preparations and micrographic plates which show us this apparatus; suppose the power of the microscope indefinitely increased, and the enlargement carried to a million or a thousand million diameters. Suppose physiology at maturity, and the theory of cellular movements as far advanced as the physical theory of undulations; suppose we knew the mechanism of the movement produced in the grey substance during a sensation, its circuit from cell to cell, its differences according as it excites a sensation of sound or of smell, the link connecting it with movements of heat or electricity, and further, the mechanical formula which represents the mass, velocity, and position of all the elements of the fibres and the cells at any time of their movement. We should even then have movement only, and movement, of whatever kind it be, rotatory, undulatory, or what else, has no resemblance at all to a sensation of bitter, of yellow, of cold, or of pain. We cannot convert either of these two conceptions into the other, and consequently the two events seem to be of absolutely different quality; so that analysis, instead of filling up the interval between them, seems to enlarge it to an infinite extent.*

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* Cf. the following extract from Professor Tyndall's Address to the British Association for the Advancement of Science, on "The Physical Forces and Thought."

"I can hardly imagine that any profound scientific thinker, who has reflected upon the subject, exists who would not admit the extreme probability of the hypothesis, that for every fact of consciousness, whether in the domain of sense, of thought, or of emotion, a certain definite molecular condition is set up in the brain; that this relation of physics to consciousness is invariable, so that, given the state of the brain, the corresponding thought or feeling might be inferred; or given the thought or feeling, the corresponding state of the brain might be inferred. But how inferred? It is at bottom not a case of logical inference at all, but of empirical association. You may reply that many of the inferences of science are of this character; the inference, for example, that an electric current

III. Repulsed in this direction, we must turn to another. It is true that we cannot conceive the two events otherwise than as irreducible to one another; but that may depend on the way in which we conceive them and not on their actual qualities; their incompatibility is perhaps rather apparent than real; it arises on our side and not on theirs. There would be nothing extraordinary in such an illusion as this. As a general rule it is sufficient for a fact to be known to us in two different ways, for us to conceive, in its place, two different facts.

Such is the case with the objects we know by the senses. A person born blind* who has just been couched, remains for a considerable time unable to reconcile his perceptions of touch with those of sight. Before the operation, he represented to himself a china cup as cold, polished, and capable of affording to the hand certain sensations of resistance, weight, and form; when he sees it for the first time, and it gives him the sensation of a white patch, he conceives the white lustrous object as something different from the resisting, heavy, cold, polished object. He would stop at this, if he did not acquire new experiences;

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of a given direction will deflect a magnetic needle in a definite way; but the cases differ in this, that the passage from the current to the needle, if not demonstrable, is thinkable, and that we entertain no doubt as to the final mechanical solution of the problem; but the passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought, and a definite molecular action in the brain occur simultaneously; we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass by a process of reasoning from the one phenomenon to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, 'How are these physical processes connected with the facts of consciousness?' The chasm between the two classes of phenomena would still remain intellectually impassable. Let the consciousness of *love*, for example, be associated with a right-handed spiral motion of the molecules of the brain, and the consciousness of *hate* with a left-handed spiral motion. We should then know when we love that the motion is in one direction, and when we hate that the motion is in the other; but the 'WHY?' would still remain unanswered."—See Report xxxviii. for the year 1868. *Transactions of the Sections*, p. 5.

* See post, Part II. book ii. chap. ii.

the two things would always be different in quality; they would form two worlds, between which there would be no communication.—And so, if your eyes are shut and you are not aware of what is going to happen, and you see a flash, then hear a sound, and then feel as if hit on the arm with a stick (the experiment may be tried on a child or an ignorant person), you will imagine that you have been struck, that some one has whistled, and that a bright light has shone into the room; and yet the three different facts are but one, the passage of a current of electricity.—The science of acoustics had to be construeted to show that the event which arouses in us, through the tactile nerves, sensations of vibration and tickling, is the same as that which, through the acoustic nerves, gives rise to sensations of sound. Till very recently "phenomena of heat,* electricity, light, ill-defined enough in themselves, were thought to be produced by so many peculiar agents, fluids possessed of special activities. A closer examination has enabled us to recognise that this conception of different specific heterogeneous elements has for foundation one single reason—namely, that the perception of these different orders of phenomena takes effect in general through different organs, and by thus attaching themselves more specially to some one of our senses, they necessarily excite special sensations. The apparent heterogeneity then would be not so much in the nature of the physical agent as in the functions of the physiological instrument by which the sensations are effected; so that by transferring, by an erroneous attribution, these differences of appearance from the effect to the cause, we should in reality have classified the intermediate phenomena by which we have cognizance of the modifications of matter, rather than the very essence of these modifications. . . . . All physical phenomena, whatever be their nature, seem to be at foundation nothing more than the manifestations of one and the same pri-

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* M. de Sénarmont. From a Lecture at the Ecole Polytechnique, cited by Saigey. "La Physique Moderne," p. 216.

mordial agent."—Thus, the conception we form bears invariably a deep imprint of the process forming it. We are compelled then to take count of this imprint; and therefore, when we find within us two ideas which have entered by different routes, we ought to mistrust the tendency which induces us to assert a difference, and above all an absolute difference, between their objects.

Now when we examine closely the idea of a sensation and the idea of a molecular movement of the nervous centres, we find that they enter by routes not merely different, but contrary.—The first comes from within, without any intermediate; the second comes from without, through several intermediates.—To represent to oneself a sensation is to have present an image of that sensation, that is to say, the sensation itself directly repeated and spontaneously reviving. To represent a molecular movement of the nervous centres is to have present images of the tactile, visual, and other sensations, which it would excite in us if it were acting on our senses from without, that is to say, to imagine sensations of white, of grey, of flabby consistency, of cellular or fibrous form, of small quivering points, that is, in fact, if we go further, to combine internally the names of movement, velocity, and mass, which denote collections and extracts of muscular and tactile sensations.—On the whole, the first representation is equivalent to its object, the second to the group of sensations which its object would excite in us. Now we cannot conceive more dissimilar processes of formation. In the case, just now, of different senses, the two representations reached us by two different roads, but both were external, so that there was nothing to prevent their having some common starting-point. Here, the two representations reach us by two opposite roads, one from within, the other from without, in such a way that these roads are perpetually divergent, and that we are unable to conceive their having the same starting-point.—Thus the fundamental opposition of the two processes of formation is sufficient to explain the mutual irreducibility of the two representations. One and the same single event known

in these two ways will appear double, and, whatever be the link which experience establishes between its two manifestations, we shall never be able to convert one of them into the other. According as its representation comes from without or within, it will invariably appear as *a thing without*, or *a thing within*, and we shall never be able to reduce that which is without to that which is within, or that which is within to that which is without.

IV. It is possible then that the sensation and the internal movement of the nervous centres may be at bottom one and the same unique event, condemned, by the two ways in which it is known, always and irremediably to appear double. Another line of reasoning leads to a similar conclusion. In fact, we have seen that our sensations are but wholes, composed of elementary sensations, that these are similarly composed, and so on; that at each of these degrees of composition the compound presents itself to us with qualities wholly different from those of its elements, that consequently, the more simple the elements, and the more removed from the grasp of consciousness, the more must they differ, as far as we are concerned, from the whole which is accessible to consciousness, in such a way that the aspect of the infinitesimal elements at the foot of the scale, and that of the whole sensation at the summit of the scale, must be wholly and entirely different. Now such is the aspect of the molecular movements when compared with that of the entire sensation. Consequently, there is nothing to prevent the molecular movements from being the infinitesimal elements of the whole sensation.—Thus, the fundamental objection is removed. If our conceptions of the mental and of the cerebral event are irreducible to one another, it may doubtless depend on the two events being, in fact, irreducible to one another; but it may also depend, first, on the event which is single, being known to us in two directly contrary ways, and, next, on the mental event and its ultimate elements being forcedly presented to us under absolutely opposite aspects.

There is room then, and equal room, for the two hypo-

theses, for that of two heterogeneous events, and for that of one and the same event known under two different aspects. Which must we choose?—If we adopt the first we are confronted with a link, not only unexplained, but inexplicable. For, the two events being by nature irreducible to one another, form two worlds, apart and isolated; we exclude by hypothesis any more general event of which they might be but distinct forms and particular cases; we declare beforehand that their nature furnishes nothing on which their reciprocal dependence may be founded. We are compelled, then, in order to explain this dependence, to seek for it in something above their nature, and therefore above all nature, for they, between them, make up all nature, consequently, then, in the supernatural. So that we must call in aid a miracle, the intervention of a superior being. The philosophers of the seventeenth century, Leibnitz and Malebranche at their head, clearly saw this consequence, and boldly decided that there was a pre-established harmony, the artificial agreement of two independent clocks, an extrinsic adjustment descending from on high, a special decree of God.—Nothing could be less conformable to the methods of scientific induction: which exclude all hypotheses by which is nothing explained.—We are driven back then to the second supposition. And, first, it is in itself as plausible as the other. Again, it has analogies and numerous precedents in its favour; for, like so many other physical and psychological theories, it takes into consideration the influence of the percipient and sentient subject, the structure of the observing instrument, the effects of optics. Besides this, it calls in no third cause, no imaginary or unknown property; it is as little hypothetical as possible. Finally, it shows not only that the two events may be connected with one another, but that they must always and necessarily be so connected. For, from the moment they are reduced to one single fact, possessed of two aspects, they evidently become like the front and reverse side of a surface, so that the presence or absence of the one will infallibly result in the presence or absence of the other.—We are

entitled then to admit that the cerebral event and the mental event are, at foundation, but one and the same event under two aspects, one moral, the other physical, one accessible to consciousness, the other accessible to the senses.

Now of the two ways in which we attain to this event, the one, consciousness, is direct: to know a sensation by consciousness, is to have present its image, which is the same sensation revived. The other way, on the contrary, that is, external perception, is indirect; it teaches us nothing as to the special characters of its object; it simply informs us of a certain class of its effects. The object is not directly manifested to us, it is denoted indirectly by the group of sensations it arouses, or would arouse in us.* In itself, excepting as to a character we shall examine later on, this physical and sensible object remains wholly unknown to us; all we know respecting it, is the group of sensations it excites in us. All we know of the cerebral molecules, are the sensations of greyish colour, of flabby consistence, of form, volume, and other analogous ones, which these molecules excite in us, directly or through the microscope, in a crude state or after preparation, that is to say, their constant effects upon us, their fixed accompaniments, their signs, nothing but their signs, *signs and indications of unknown things*.—There is, then, a great difference between the two aspects. By consciousness, I attain the fact itself; by the senses, I attain a sign only. A sign of what? What is it that is constantly accompanied, denoted, *signified* by the internal movement of the nervous centres? We have shewn this previously when explaining the conditions of sensations and images; it is the sensation, the image, the internal mental event. All is then in accordance. This mental event which consciousness attains directly, can only be attained indirectly by the senses; the senses know nothing of it but its effect on them; that is why they cause us to conceive it as a cerebral

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* See *post*, Part ii. book ii. chaps. 1 and 2. See, too, the admirable chapters on the Theory of the Belief in an External World and on the Primary Qualities of Matter, in Mill's "Examination of Sir W. Hamilton's Philosophy."

movement of grey cells; as it acts on them from without only, it cannot appear to them otherwise than as external and physical.—Here is a direct and remarkable confirmation of the admitted hypothesis, and we now understand how it is the mental event being single, necessarily appears double; the sign and the event signified are two things which can no more be confounded than separated, and their distinction is as necessary as their connexion. But, in this connexion and in this distinction, all the advantage is on the side of the mental event; it alone exists; the physical event is but the way in which it affects or is capable of affecting our senses. The physical world, then, is reduced to a system of signs, and all that remains to enable us to construct and conceive it are the materials of the moral world.

What are these materials? We have seen that the sensation, strictly so called, is a compound of successive and simultaneous events of the same quality, themselves composed in the same way; that at the extremity of our analysis, indirect experience and analogies still show successive and simultaneous events of the same quality, all remote from consciousness and becoming at last infinitesimal; that reflex actions indicate analogous rudimentary events, and that these may be traced even at the lowest point of the animal scale, even in animals like the fresh-water polypus in which no trace of a nervous system has been found.*—But they may be traced still further than this; for, in many plants like the sensitive plant and the oscillating clover of Bengal, in the antherozoides of the cryptogamia and the zoospores of the algæ, reflex actions are met with wholly similar to those produced by the trunk of a decapitated frog. "There is no radical difference between animals and vegetables," when looked at in this light.—No more again is there when looked at in the light of internal structure, or of chemical composition. The two kingdoms are so confounded together in their lower branches, that many groups, among

* Vulpian, 43, 37, 31.

others the Vibriæ, have sometimes been classified in the one, sometimes in the other. In fact, "the nervous system is but a perfectioned apparatus," and the mental event of which it is the condition, and of which its action is the sign, is a complex and organized group whose elements and rudiments may also be met with elsewhere.—By pursuing analogies then, we may descend still lower in the scale of beings. Beneath the organic world extends the inorganic, and the first is but a case of the second. It is constructed with the same chemical substances, subject to the same physical forces, governed by the same mechanical laws, and all the indications of science concur in representing it as differing in degree but identical in nature ;* what we term life is a more delicate chemical action of more complex chemical elements. In pursuing our analysis, from the highest operations of the cerebral lobes to the most elementary phenomena of physics, we find nothing but mechanical movements of atoms, transmissible without loss from one system to another, and so much the more complicated as the systems become more complex. By correspondence, the same degradation and the same reduction occur in mental events ; at the highest degree of complication, they constitute images, sensations, strictly so called, and those rudimentary sensations which reflex action denotes ; in the next degrees, they are still events of the same kind, but less compound, and so on, their complication diminishing with that of the molecular movement, till at last, to the most simple degree of the physical event, corresponds the most simple degree of the mental event.

V. Nature, then, has two faces, and the successive and simultaneous events of which she is made up may be conceived and known in two ways, internally and in themselves, externally and by the impression they make on our senses. The two faces are parallel, and every line cutting the one cuts the other at the same level. When seen from

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* Berthelot, "Chimie Organique," ii. conclusion. Bérard, "Eléments de Physiologie," ii. 65. Saigey, "De l'Unité des Phénomènes Physiques," *passim.*

the one side, nature has, as elements, events of which we can know nothing except when in a state of extreme complication, and which, in this state, we term sensations. Seen from the other side, she has, as elements, events which we can only conceive clearly when in a state of extreme simplicity, and which, in this state, we term molecular movements. From the first point, she is a scale of successive and simultaneous mental events, whose complication goes on *decreasing*, if we start from the summit of which we are conscious, to descend to the base of which we are unconscious. From the second point, she is a scale of successive and simultaneous physical events, whose complication goes on *increasing*, if we start from the base which we clearly conceive, to ascend to the summit of which we have no precise idea. Every degree of complication on one side of the scale indicates an equal degree of complication on the other. On both sides, at the base of the scale the events are infinitesimal; we have seen in the case of those sensations which we have been able to a certain extent to analyse, those of hearing and sight, that the mental event, as the physical event, passes in a very short time through a strictly infinite series of degrees. From base to summit, the correspondence on either side is perfect. Phrase for phrase, word for word, the physical event, as we represent it to ourselves, *translates* the mental event.

Let the reader follow out the comparison to the end; it will express the matter with all its details. Suppose a book written in an original tongue and furnished with an interlinear translation; the book is nature, the original language is the mental event, the interlinear translation is the physical event, and the order of the chapters is the order of beings.—At the beginning of the book, the translation is printed in clear and legible characters. But these become less so, as we go on, and here and there, from chapter to chapter, new characters creep in, which we have difficulty in connecting with the earlier ones. At last, and above all in the final chapter, the impression can no longer be deciphered; but we have abundance of evidence that it

is still the same book and the same language.—It is just the reverse with the original text. It is very legible at the last chapter; in the one before it the ink is pale; in earlier chapters we can still discover that there is printing, but can read nothing of it; before that again, all trace of ink has disappeared.

Such is the book philosophers attempt to understand; before the final unintelligibility of the first writing, and before the enormous gaps of the second, they stop embarrassed and each one decides, not from the facts in evidence but from the habits of his mind and the wants of his heart.—Scientific men properly so called, physicists and physiologists who have begun the book at the beginning, say that it contains but one language, that of the interlinear translation, and that the other is reducible to it; an enormous supposition, since the two languages are wholly different.—Moralists, psychologists, and religious minds who have commenced the book at the end, and are nevertheless forced to confess that the bulk of the work is written in another idiom, find an inexplicable mystery in this assemblage of two languages, and usually declare that there are two books put in juxtaposition and beside one another. In short, materialists disallow the text, and spiritualists declare the connexion of text and translation to be inexplicable.—We have not proceeded in this way, and our minute analysis has led us to a new solution. We have first studied for a long time the original idiom, and have shown that the pages of the last chapter, which appear to be written in various kinds of characters, are all written in the same character. Profiting by this reduction, we have then deciphered many half-obliterated lines of the chapter preceding it; then, from the vague traces left on the earlier pages, we have conjectured that the text is continued much further back, even on those pages on which no trace of it is visible. We then proved the interlinear writing to be a translation, and the other to be an original text; and have concluded, from their dependence, that the first is the translation of the second. On this evidence we have admitted

that the text, though invisible to our eyes, must be continued on the earlier pages, and that, on the final pages, the interlinear writing, though it cannot be deciphered, is still a translation. In this way, the unity of the book has been proved, and the two idioms are completed or explained by one another. We now know which of them is the original testimony and deserves our confidence, and to what extent and with what assurance we may consult the other. Thanks to their mutual dependence and to the continual presence of one or other of them, each of them may supply the place of the other. When one of them is effaced or incapable of being deciphered, we are entitled to draw conclusions, from the one we can read, to the other which has become unreadable.*

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* To complete this theory, see *post*, note at end of sect. vii. chap. 1, book ii. part ii.

CHAPTER III.

THE HUMAN PERSON AND THE PHYSIOLOGICAL INDIVIDUAL.

I. Hitherto we have considered our events, without occupying ourselves with the being they appertain to, and which each of us calls *himself*. We must now examine this being. Philosophers usually give it the principal place, and a place wholly distinct. "I experience sensations, say they, I have recollections, I combine images and ideas, I perceive and conceive external objects. This *Ego* or *self*, unique, persistent, and always the same, is something different from my sensations, recollections, images, ideas, perceptions, and conceptions, which are various and transient. Besides this, it is capable of experiencing some of these and of producing the rest; and thus it possesses powers or faculties. Now these faculties reside in it in a stable manner; by them it feels, recollects, perceives, conceives, combines images and ideas; it is, then, an efficient and productive cause."—Thus they arrive at considering the Ego as a subject or substance, having for its distinctive qualities certain faculties, and they suppose that, beneath our mental events, there are two kinds of explicative entities, first the powers or faculties experiencing or producing them, then the subject, substance, or soul possessing these faculties.*

Now these are metaphysical entities, pure phantoms, begotten of words, and vanishing as soon as we examine rigorously the meanings of the words. What is a power?—A despotic sovereign has absolute power; this means that, as soon as he commands a thing to be done, whatever

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* Garnier, "Traité des facultés de l'âme," vol. i. books i. and ii. See Jouffroy and Maine de Biran for the theory of these scholastic entities.

it may be, the confiscation of property, the death of a man, it will be done.—A constitutional king has limited power only; this means that if he commands certain things, the dismissal of a minister, the promulgation of a law, they will be done; but that, if he orders other things, such things, for instance, as we mentioned just now, they will not be done; this is all that is meant. All that the word power here denotes is a constant connexion between one fact, the order of a prince, and certain other facts following it.—And so again we say that a healthy man has power to walk and a paralytic man has not; this simply means to say that, in the healthy man, the resolution to walk is certainly followed by the movement of his legs, and this resolution is never so followed in the case of the paralytic; here again power is but the perpetual connexion between one fact which is antecedent and another which is consequent.

So again with force. A particular horse has force enough to draw a cart weighing five thousand kilogrammes, and has not force enough to draw the same cart when more heavily loaded. A particular stream of water has force enough to move a wheel, and has not force enough to move a heavier wheel. This means that, when the horse's muscles are contracted, the cart of five thousand kilogrammes will be moved, and the other cart will not be moved; that when the stream falls on the boards of the wheels, the first one will turn and the second one will not. Here we have connexions only, one between the muscular contractions of the horse and the movement of the cart; the other between the stream of water and the wheel turning round. A particular force exists when a particular connexion exists; it ceases when this connexion ceases. When two events are connected, and the second of them has a particular magnitude when compared to others similar to it, we say that the force has a particular magnitude. When the magnitude of the second event is double, the magnitude of the force is double. The force of the muscular contraction is double, if the cart moved

weighs ten thousand kilogrammes instead of five thousand; the force of the stream of water is double, if the wheel set turning is twice as heavy as the first wheel. In general, if we are given two facts, one antecedent and the other consequent, connected by a constant link, we term the particularity of the antecedent to be always followed by the consequent, force, and we measure this force by the magnitude of the consequent.

The names power and force, then, do not denote any mysterious being, any occult essence. When I say that I have power or force to move my arm, I merely wish to say that my resolution to move my arm is constantly followed by the movement of my arm. In fact, if, with the aid of physiology, I examine this operation somewhat more closely, I find in it a number of intermediate steps—a molecular movement in the cerebral lobes, another molecular movement in the cerebellum, another molecular movement propagated along the marrow, and thence into the motor nerves of the arm, a contraction of the muscles of the arm, a displacement of their points of attachment. I have power to move my arm in the same sense that a person working the telegraph at Marseilles has power to move the telegraph needles at Paris. Between my resolution and the displacement of my arm, there are all the intermediate steps enumerated; between the operator at Marseilles and the needles at Paris, there are a thousand kilometres of telegraph wire. It is a constant particularity that the signals of the worker are followed a thousand kilometres off by the play of the indicating needles; it is a constant particularity that my resolution is followed, through ten indispensable intermediate links, by the movement of my arm. There is nothing more than this.—Unfortunately, of this particularity, which is a relation, we construct, by a mental fiction, a substance; we describe it by a substantive name, force or power; we attribute qualities to it; we say that it is greater or less; we employ it in language as a subject; we forget that its existence is wholly verbal, that it derives it from ourselves, that it has received it by way of loan, provision-

ally, for convenience of discourse, and that, being simply a relation, it is nothing in itself. Led away by language and custom, we suppose there is something real in it, and reasoning from false premises, increase our error at every step.—In the first place, as the being in question is a pure nonentity, we can find nothing in it but emptiness; this is why, by an illusion of which we have already seen instances,* we make of it a pure essence, unextended, incorporeal, in short, spiritual.†—In the second place, as the event only arises through this force, the event is wanting if the force is wanting; the force is the cause of the event. Besides this, it precedes and survives the event; it is permanent while the event is transient; the event may be repeated or changed, the force is always one and the same; it may be compared to an inexhaustible stream, of which the event is a wave. Hence we come to consider it as an essence of a higher order, placed above the facts, stable, monadic, creative. From its model, philosophers go on to people the universe with similar entities. And yet, it is in itself nothing more than a character, a property, a particularity of a fact, the particularity of being always followed by another fact, a particularity detached from the fact by abstraction, set apart by fiction, kept in a distinct state by means of a distinct substantive name, till the mind, forgetting its origin, believes it to be independent, and becomes the dupe of an illusion of its own effecting.

II. The fall of this illusion causes the fall of another. "Power," say the spiritualists, "identifies itself with the being possessing it. . . . . That something by which *we can* ought not to be considered as distinct from the soul."‡ The faculties and forces of the Ego, then, are the Ego itself,

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* See *ante*, book i. chap. 3, p. 33.

† "Causes are not material; their activities are necessarily immaterial. Forces seize on matter, conform it to themselves and manifest themselves by their effects on its surface, they are signified and interpreted by the qualities they impose on matter. . . . . The real cause which sets in motion the heart, the stomach, and other organs, is external and superior to those organs."—Jouffroy, "Esthétique," 132, 145; "Nouveaux Mélanges," 233 to 273.

‡ Garnier, "Traité des facultés de l'âme," i. 44.

or at least a portion of the Ego; many spiritualists go so far as to admit, with Leibnitz, that the Ego is nothing more than a force, and that in general the notions of force and substance are equivalent. Now we have just seen that powers and forces are but verbal entities and metaphysical phantoms So far, therefore, as it is made up of forces and powers, the Ego itself is but a verbal entity and a metaphysical phantom. That inner something of which the faculties were different aspects, disappeared with them; the one permanent substance, distinct from events, is seen to vanish and re-enter the region of words. All that remains of us are our events, sensations, images, recollections, ideas, resolutions: these are what constitute our being; and the analysis of our most elementary judgments shows, in fact, that our Self has no other elements.

Take a sensation of taste, then a pain in the leg, then the recollection of a concert. I taste, I suffer, I recollect. In all these words we find the verb *to be*, and all these judgments contain the subject *I*, connected by the verb *to be*, with a participle denoting an attribute. Now, in every judgment, the verb *is* expresses that the attribute is an element, a fragment, an extract of the subject, included in it, as a portion in a whole; this is the whole sense and office of the verb *to be;* and it is the same with it here as in other cases. Here, then, the verb expresses that the sensation of taste, the pain, the recollection of the concert, are elements, fragments, extracts of the Ego. Our successive events then are successive components of ourselves. The Ego is in turn each of these events. At one moment, as was clearly seen by Condillac, it is nothing more than the sensation of taste, at the second moment, nothing more than suffering, at the third, nothing more than the recollection of the concert.—Not that it is a simple whole; for the verb *is*, which connects the subject to the attribute, expresses, not only that the attribute is included in the subject as a portion in a whole, but further, that the existence of the whole precedes its division. Whatever be the origin of a judgment, the attribute is always, in relation

to the subject, an artificial fragment in relation to a natural whole. The mind extracts the fragment, but, at the same moment, recognises that this extraction or abstraction is purely fictitious, and that, if the fragment exists apart, it is from the mind's having set it apart. In fact, it is simply for the convenience of studying them that we separate our events from one another; they actually form a continuous web in which our inspection sets boundaries by arbitrary severings.* The operation we perform resembles that of a man who the better to know a long plank divides it into triangles, rhomboids, and squares, all marked out with chalk. The plank remains one and continuous; we cannot say that it is simply the series of its portions placed end to end, since it is only divided to the eye; but still it is equivalent to the series of these portions; if they were taken away, nothing would remain; they constitute it. In the same way the Ego remains one and continuous; we cannot say that it is the series of its events placed in succession, since it is not divided into events except to observation; but still it is equivalent to the series of these events; if they were taken away, nothing would remain; they constitute it.—When we separate them from it, we do as a man would who should say, after going over the several divisions of the plank, "This plank is a square here, just now it was a rhomboid, presently it will be a triangle; through all my advancing, retreating, recalling the past, foreseeing the future, I always find an invariable, identical, single plank, though its divisions vary; it then is different from them, it is a distinct subsisting being, that is to say, an independent substance of which the rhomboids, triangles, and squares are but successive states." By an optical illusion, such a man would create an empty substance—the plank in itself. By a similar mental illusion, we create an empty substance—the Ego in itself.—Just as the plank is nothing more than the continuous series of its successive divisions, so, the Ego is nothing more than the continuous web of

* "Les Philosophes Français du xix^me^ Siècle," par H. Taine, 3rd ed. p. 250.

its successive events. If we consider it at a given moment, it is nothing more than a portion severed from the web, that is to say, a group of simultaneous events, about to be made up and then undone, some salient sensation among other less salient ones, some preponderant image among others about to fade away. At any other moment, the portion severed is analogous; it is no other and no more than this.

If now we classify these various events, sensations, images, ideas, resolutions; if we impose a name on each class, sensibility, imagination, understanding, will; if we attribute to the Ego various powers, that of feeling, that of imagining, that of willing; this is permissible and useful. But we must never forget what underlies these words; we mean simply to say that this being feels, imagines, thinks, wills, and that, if things remain the same, it will feel, imagine, think, and will. When we outstep this vague proposition, we mean to say that, certain conditions being given, this being will have a certain sensation, image, idea, or resolution, in other words, that in the web constituting it there is a constant connexion with some event internal or external.—I have the power of recalling a picture, the Marriage at Cana by Véronèse; this means that at my present time of life, and with my present memory, the resolution to recall the picture is constantly followed, after the lapse of a certain time, by the internal revival, more or less clear and complete, of the figures and architecture of which the picture is composed.—I have the faculty of perceiving an external object, this table, for instance; this means that in my present state of health, without amaurosis, or tactile muscular paralysis, if the table be in the light, if it be within the range of my hand and my eyes, if I turn my eyes towards it, or stretch out my hand upon it, these two actions will be constantly followed by the perception of the table.—The forces, faculties, or powers appertaining to this web are nothing more, then, than the property which any particular event of the web has of being constantly followed, under various conditions, external or internal, by some particular internal or external

event. There is nothing in the web, then, but its events, and the more or less distant connexions which they have with one another or with external events; and the Ego, that is the web, contains nothing beyond its events and their connexions.

The destruction of this metaphysical phantom lays low one of the principal survivors of that army of verbal entities which formerly invaded all the provinces of nature, and which, during the last three hundred years, the progress of the sciences has one by one upset. There are two only left at present, the Ego and matter; but at that time, during the avowed or dissembled empire of the scholastic philosophy, men imagined that, underlying events, were a number of chimerical beings—the vital principle, the vegetative soul, substantial forms, occult qualities, plastic forces, specific virtues, affinities, appetites, energies, archæa, in short, a population of mysterious agents, distinct from matter, connected with matter, and believed to be indispensable to explain its transformations. They have gradually vanished at the contact of experience. Now-a-days, when scientific men speak of forces, physiological, chemical, physical, or mechanical, they see that these names are names only. Their efforts are limited to the proof of constant connexions; when they explain a fact, it is by means of another fact. At the highest point of their theories,* they establish couples of very general events, the first antecedents, the second consequents, the second following the first without exception or condition; from these couples, they deduce other things. If they use the word force it is to denote the constant connexion between the second and the first. If they admit different forces, it is because, in the present state of our knowledge, the couples to which certain groups of events are reduced cannot be reduced to one another or to other couples. In short, verbal entities no longer subsist except at the two extremities of science—in psychology, by the notion of self

* See Mill's "Logic," and especially the theory of Induction.

and its faculties; in the preliminary parts of physics by the notion of matter and of its primitive forces.—Hitherto, and in France especially, this illusion has obstructed psychology; men have applied themselves to observing the pure Ego; they have attempted to see in the faculties "the causes which produce the phenomena of the soul;"* they have studied the reason—the faculty which produces ideas of the infinite, and discovers necessary truths; the will—the faculty which produces free resolutions. They have thus constructed a science of words alone. "From a pictured hook," says an English philosopher, "we can hang only a pictured chain." Let us lay aside words, let us study events, which alone are real, their conditions, their dependences, and it is certain, that by following the path struck out by Condillac, and cleared by James Mill and his English successors, we shall gradually arrive at the construction of a science of things and of facts.

III. Having upset this entity at the summit of nature, there remains, at the foot of nature, another entity, matter, which falls by the same blow. Hitherto, the most faithful followers of experience have admitted, at the foundation of all corporeal events, a primitive substance, matter possessed of force. Positivists themselves underwent this illusion; in spite of their reducing all knowledge to the discovery of facts and their laws. Beyond the accessible region of facts and laws, they placed an inaccessible region, that of substances, real things, the knowledge of which would certainly be most precious, but in whose direction research ought not to stray, since experience attests the futility of all inquiry respecting them. Now the analysis which reduces substance and force to verbal entities is applicable to matter as well as to mind. In the physical as in the moral world, force is that particularity which a fact has of being constantly followed by another fact. Isolated by abstraction, and denoted by a substantive name, it becomes a permanent subsisting being,

* Garnier, "Traité des Facultés de l'Âme," i. 33.

that is to say, a substance. But it becomes so for the convenience of discourse only, and the attempt to make anything more of it, is founded on a metaphysical illusion like that which sets apart the Ego and its faculties. Scientific men themselves come involuntarily to this conclusion when, provided with mathematical formulæ and with the whole of the facts of physics, they attempt to conceive the ultimate particles of matter.* For they arrive at picturing atoms, not according to the coarse imagination of the crowd, as little solid masses, but as pure geometric centres, with relation to which, first, attractions, then repulsions increase with increasing proximity. In all this there are but movements, present, future, or possible, connected with certain conditions, variable in magnitude and direction according to a certain law, and determined with relation to certain points.

Thus, in the physical as in the moral world, nothing remains of what is commonly understood by substance and force; all left subsisting are events, their conditions and dependences, some of them moral or conceived on the type of sensation, others physical or conceived on the type of motion. The notion of *fact or event* alone corresponds to real things. In this way, the Ego is a being as much as the chemical body or material atom; only it is a more compound being, and consequently subject to more numerous conditions of origin and conservation. Chemical body, material atom, self—that which we term a being, is always a distinct series of events; what constitutes the forces of a being is the property of certain events of its series to be constantly followed by some particular event of its own or of another series; what constitutes the substance of a being is the permanence of this and other analogous properties. This is why, if we cast a general glance over nature, and drive out of our minds the phantoms we have set up between her and our thought, we perceive in the world nothing more than simultaneous series of successive events,

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* Renouvier, "Essais de Critique Générale," 3me essai, 25, Exposition of the Ideas of Boscovich, Ampère, Poisson, and Cauchy.

each event being the condition of another and having another as its condition.

IV. This being settled, we have no difficulty in comprehending the connexion between the human personality and the physiological individual. For it is now no longer a question of knowing how an unextended substance, termed soul, can dwell in an extended substance, termed body, or how two beings of nature so different can hold intercourse with one another; these scholastic questions fall to the ground with the scholastic entities which suggested them. All we have now before our eyes is a series of events termed self, connected with other events forming its condition. Henceforward, there is nothing strange in the dependences we have proved. The web of facts which makes up our being is a distinct district in the aggregate constituted by the nervous functions, this aggregate itself being a distinct province in the entire living animal. As we have shown, this web may be considered under two aspects, directly, in itself and by consciousness, or indirectly, by external perception and from the impressions it produces on the senses.—Next to ideas, images, and sensations, events of a very compound nature, of which we are conscious, and which are thus distinguished from other analogous events, are other rudimentary and elementary events of the same kind, of which we are not conscious, and whose existence is denoted by the reflex action: such is the first aspect.—Next to the very compound molecular movements which take place in the grey substance of the cerebral lobes and of the centres termed sensory, are other analogous but less compound molecular movements which take place in the grey substance of the marrow and the ganglia of the sympathetic nerve;* this is the second aspect.—The first is the psychological aspect; the second is the physiological aspect.—According to the second, there are in the animal many centres of nervous action, the ganglia of the great

* Experiments of Claude Bernard on the reflex power of the submaxillary ganglion.

sympathetic nerve, the different segments of the marrow, the different departments of the encephalon, more or less subordinate or predominant, more or less simple or complex, but all distinct, mutually excitable, and possessed of the same fundamental properties.—According to the first, there are in the animal many groups of mental events, ideas, images, sensations strictly so called, rudimentary and elementary sensations, all more or less subordinate or predominant, more or less simple or complex, but distinct, mutually excitable, and more or less analogous to sensation.—By somewhat straining language, we might consider the marrow as a string of rudimentary encephala, and the ganglia of the sympathetic nerve as a network of still more rudimentary encephala.* Consequently, we should see, in the groups of rudimentary sensations of which we are not conscious, rudimentary souls; and just as the nervous apparatus is a system of organs in different states of complication, so the psychological individual would be a system of souls in different degrees of development.

We must not take these metaphors for more than they are worth, that is to say, for phrases translating into ordinary language the positive facts we have proved. But, as we descend the animal kingdom we constantly find them becoming more and more exact; the mutual dependence of the nervous centres becomes less strict; each centre is less affected by being cut off from the rest; and when isolated, performs its functions less incompletely and for a longer time. We have seen that, in a triton or a frog, the hindquarters go through complex movements when separated from the rest of the body, movements adapted to a purpose, and capable, under altered circumstances, of adapting themselves to another purpose. These co-ordinated movements which seem to denote an intention, are still more visible in the severed portions of insects.† This extends so

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* See Landry, "Des Paralysies," 47, cited ante, p. 184.

† Vulpian, op. cit. 790. Experiments of Dugès, Dujardin, Walkenaer, &c. Dugès, "Physiologie Comparée," i. 337.

far, that many observers have seen in such movements a true intention, and consequently true representations, just as those of which the cerebral lobes are the organs. "I remove rapidly with scissors," says Dugès, "the anterior segment of the thorax of the *Mantis religiosa*. The posterior part of the body still remains balanced upon the four legs which belong to it, resisting any attempt to overthrow it, recovering its position when disturbed and performing the same agitated movements of the wings and elytra, as when the unmutilated insect is irritated. . . . . The experiment may be pursued in a more striking manner. The anterior part of the thorax contains a bilobed ganglion, sending out nerves to the arms or fore-limbs, which are armed with powerful claws. If the head be removed, the detached portion will then live for nearly an hour with its solitary ganglion; it will set in motion its long arms, and knows how to turn them against the fingers of the experimenter who holds it, and to insert its hooks in them."

If we descend a step lower, the fundamental plurality of the animal will become more evident. "With the Annelids, each ganglion corresponds to a segment of the body, often formed of many rings, as for instance, with leeches, all whose parts are repeated with every five rings. Every segment thus possesses, besides this ganglion, a similar portion of the principal apparatus, sometimes even of the apparatus of the senses. This is the case with the Polyophthalmus, in which each segment is provided with two rudimentary eyes, each receiving a nervous thread from the corresponding ganglion, a real optic nerve." Each of these segments is a complete animal, and the whole animal is formed "of several elementary animals placed one after another." Thus it is that, when separated, each is still an independent centre of co-ordinated reflex actions adapted to an end. Now the only difference between a nervous system so constituted, and the nervous system of a mammal, is that the segments of the first are more complete and independent than those of the second. In fact, anatomy shows that a vertebral column, like an annelid, is

composed of distinct segments, medullary and protecting, that the skull itself is made up of flattened and consolidated vertebræ, and that the brain is nothing more than a prolongation and development of the spinal marrow. In short, the republic of nervous centres, all equal and almost independent, which we meet with among the inferior animals, is gradually changed as we ascend to the superior animals, into a monarchy of unequally developed and intimately connected centres subject to one principal centre.—But this advanced organization and centralization do not suppress the original plurality of the being so constituted. In proportion as it rises in the scale, it departs from the state in which it was a total, and approaches the state in which it will be an individual; that is all. Even when in the state of an individual, we can push it back into the state of a total; by effecting transverse segments in the marrow of a young mammal, it is possible, if circulation and respiration go on, to maintain in it, for several weeks, independent segments, each capable of reflex action, and incapable of receiving from or transmitting to others any excitation whatever.* Lastly, at the lowest point of the animal scale, with zoophytes for instance, in which no nervous system is apparent, and in which nervous matter probably exists in a diffused state only, the plurality and division are much greater still; for a polypus may be cut in every direction, and even chopped up; each fragment becomes complete, and furnishes an animal having all the faculties and instincts of the primitive animal.

The reader sees now how the web of events, which is ourselves, and of which we have consciousness, is connected with the rest. This series—which, according to the aspect in which we consider it, is sometimes, to our senses, a series of molecular movements, sometimes, to our consciousness, a series of sensations, more or less transformed—is nothing more than the most complex and most predominant in a group of other analogous series. In

* See *ante*, p. 184.

proportion as we descend the animal scale, we see it lose its domination and complexity, and become reduced to the level of the others, while these in turn loosen their mutual connexions, and become insensibly degraded.—To external perception, they have all for condition of existence, the integrity and renewal of the nervous system whose special activity they are, and the beings, more or less strictly bound together, which they constitute, whatever they may be to consciousness, with whatever names metaphysical or literary illusion may clothe them, are subject to the same condition.

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